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Blacks Fork Watershed
Total Maximum Daily Loads

Public Draft Implementation Plan

Prepared for

Wyoming Department of Environmental Quality

Prepared by

SWCA Environmental Consultants

June 2014

BLACKS FORK WATERSHED
TOTAL MAXIMUM DAILY LOADS

PUBLIC DRAFT IMPLEMENTATION PLAN

Prepared for

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GLOSSARY AND ABBREVIATIONS

AFO	animal feeding operation
AUE	animal unit equivalent
BLM	Bureau of Land Management
BMP	best management practices
BSLC	bacteria source load calculator
DMR	discharge monitoring report data
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
G-cfu	giga colony forming unit (defined as 10^9 colony forming units of bacteria)
GIS	geographic information system
Key areas	Subwatersheds identified as those where BMP implementation could be most effective based on the proportion of *E. coli* load contribution.
LA	load allocation
MGD	million gallons per day
mL	milliliters
NRCS	Natural Resources Conservation Service
Subirrigation	As defined by the Wyoming Water Development Commission, these are lands that appear to be receiving irrigation water based on aerial imagery analysis but have no appropriated water right.
SWCA	SWCA Environmental Consultants
TMDL	total maximum daily load
UCCD	Uinta County Conservation District
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WDEQ	Wyoming Department of Environmental Quality
WLA	wasteload allocation
WWTP	wastewater treatment plants
WYPDES	Wyoming Pollutant Discharge Elimination System

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1. INTRODUCTION

The Blacks Fork Watershed implementation plan outlines a strategy for reducing *Escherichia coli* (*E. coli*) loads to attain water quality standards for pathogens in several impaired reaches. When combined with current implementation planning, management measures, and *E. coli* reduction efforts, completion of the proposed implementation plan could result in rivers that are healthy and productive for use by current and future generations. This implementation plan builds off the Blacks Fork Watershed Total Maximum Daily Load (TMDL) (SWCA Environmental Consultants [SWCA] 2014), a document that represents the TMDL analyses of four impaired reaches of the Blacks Fork and Smiths Fork Rivers within the greater Blacks Fork Watershed in fulfillment of Clean Water Act requirements. The Wyoming Department of Environmental Quality (WDEQ's) Water Quality Division (WQD) collects biological and water quality data to evaluate the quality of the waters of the State of Wyoming. Based on this assessment, two reaches of Blacks Fork and two reaches of Smiths Fork were included on the State of Wyoming's 303(d) list in 2000 for exceedances in *E. coli* and fecal coliform. It should be noted that recent data from Reach 2 indicate that an impairment no longer exists; however, it has not been officially delisted and therefore still maintains a "not supporting" designation. As such, it is considered in the source analysis assuming a 0% reduction.

A TMDL analysis determines the amount of an identified pollutant (i.e., the load) that a waterbody can receive while preserving its designated uses and state water quality standards. Once the pollutant loads have been identified, controls are implemented to reduce those loads until the waterbody is brought back into compliance with water quality standards. Upon completion of the TMDL analysis, it is submitted to WDEQ and the U.S. Environmental Protection Agency (EPA) for approval. The overall goal of the TMDL process within the greater Blacks Fork Watershed is to restore and maintain water quality in the impaired reaches of the Blacks Fork and Smiths Fork Rivers to a level that protects and supports their designated uses (e.g., drinking water, game and non-game fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, and scenic value). SWCA developed this TMDL under the direction of the WDEQ.

This implementation plan includes the nine key elements identified by the EPA that are considered important for achieving improvements in water quality (EPA 2008). The EPA requires that these nine elements be addressed in watershed plans funded with incremental Clean Water Act (CWA) Section 319 funds, and strongly recommends that they be included in all watershed plans intended to address water quality impairments. Although there is no formal requirement for the EPA to approve watershed plans, the plans must address the nine elements discussed below if they are developed in support of Section 319–funded projects (EPA 2008). This implementation plan demonstrates that the *E. coli* load reductions identified in the total maximum daily load (TMDL) can be attained through implementation of best management practices (BMPs) throughout the watershed. The project implementation plan identifies source-specific BMPs, key areas for implementation, a timeframe for implementation, a monitoring plan, and unit costs associated with recommended structural BMPs.

The EPA's nine elements are listed below in the order they appear in the guidelines; however, it should be noted that although they are listed as *a* through *i*, they do not necessarily need to be completed sequentially.

a) Identify and quantify causes and sources of the impairment(s).

b) Estimate load reductions needed to meet water quality standards.

c) Identify BMPs needed to achieve load reductions and key areas where these management measures will be implemented.

d) Estimate needed technical and financial resources.

e) Provide an information, education, and public participation component.

f) Include a schedule for implementing nonpoint source management measures.

g) Identify/describe interim measurable milestones for implementation.

h) Establish criteria to determine if load reductions/targets are being achieved.

i) Provide a monitoring component to evaluate effectiveness of the implementation over time for criteria in h.

For the purposes of this implementation plan, BMPs refer to any action or measure implemented or maintained in the watershed to mitigate nonpoint sources of *E. coli* to waters in the Blacks Fork Watershed. These include traditional structural and nonstructural BMPs, as defined by the Natural Resources Conservation Service (NRCS), the U.S. Forest Service (USFS), and the Bureau of Land Management (BLM), as well as actions and measures related to planning and cooperation with stakeholders. Recommendations for nonpoint source reductions consider all sources and are based on management measures that consider BMPs, effectiveness, attainability, cost, and the distribution of responsibility for water quality improvement among all users in the watershed.

The implementation strategy for reducing *E. coli* is an iterative process where data are gathered on an ongoing basis, sources are identified and mitigated if possible, and control measures such as BMPs are implemented, assessed, and modified as needed. Measures to abate probable sources of *E. coli* include public education outreach, reducing loads from inadequate and/or failing septic systems, and managing rangeland. Implementation of a suite of BMPs, as described in this plan, provides assurance that *E. coli* load reductions can be achieved and designated uses can be restored. Strategies presented in the following implementation plan for reducing nonpoint sources are recommendations and serve only to act as a guideline for stakeholders interested in reducing *E. coli* loads to surface waters.

For the purposes of watershed planning, implementation strategies and recommendations are structured around reductions in Reach 1, defined as Blacks Fork from Smiths Fork upstream to Millburne and consisting of the Lyman and Fort Bridger subwatersheds; Reach 3, defined as Smiths Fork from Blacks Fork upstream to Cottonwood Creek, consisting of the Lower Smiths Fork subwatershed; Reach 4, defined as Smiths Fork from Cottonwood Creek upstream to the East Fork and West Fork of Smiths Fork, consisting of the Upper Smiths Fork and Smiths Fork subwatersheds and Reach 2, defined as Blacks Fork from Hams Fork upstream to Smiths Fork, and consisting of the Lower Blacks Fork subwatershed. The following implementation plan is focused at the subwatershed level to more accurately identify key areas and recommend appropriate implementation strategies (Figure 1.1). Detailed data sources and methodology for the source load analysis are described in section 3 and section 4 of the TMDL (SWCA 2014).

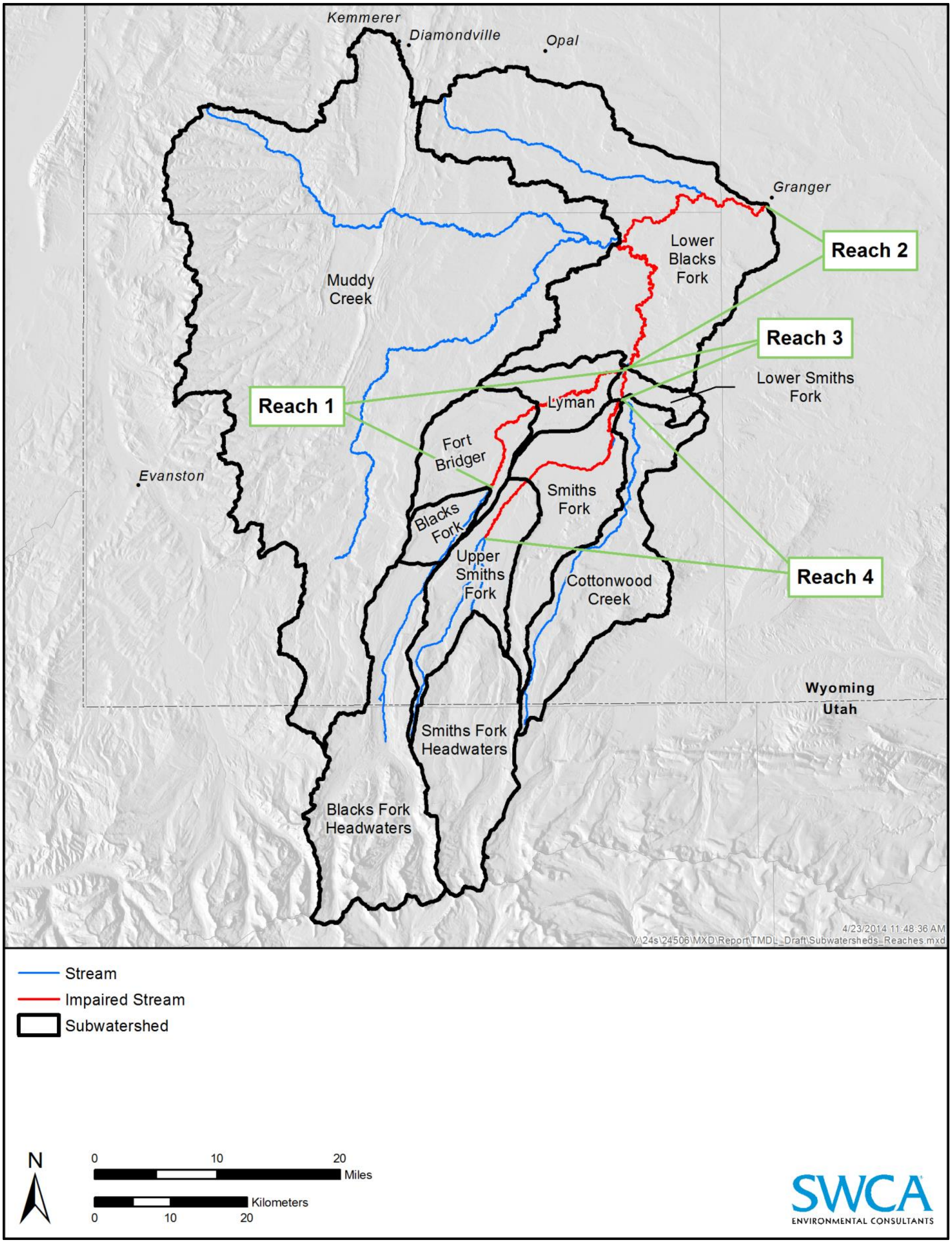

Figure 1.1. Impaired reaches and associated subwatersheds used for source identification and characterization in the Blacks Fork watershed.

2. KEY ELEMENTS OF THE IMPLEMENTATION PLAN

2.1. Identification of Sources and Current Load Summary (element a)

This section provides a summary of and rationale for all significant *E. coli* sources that contribute to impairments in the Blacks Fork Watershed. Contributing point sources consist of three wastewater treatment plants (WWTPs) in the towns of Lyman, Mountain View, and Fort Bridger, and a truck stop off Interstate 80 near the town of Fort Bridger that consists of a contained wetland. Nonpoint sources of *E. coli* include agricultural activities, septic systems, pet waste, and wildlife. Agricultural activities consist of grazing on both public and private land as well as flood irrigation practices. Loads entering the subwatersheds from upstream are also of interest because they can contribute significantly to the total load, particularly in the Lower Smiths Fork and Lyman subwatersheds. Characteristics for each subwatershed that illustrate the relative importance of specific sources as well as total load contribution during the impairment season by subwatershed are summarized in Table 2.1. Contributions from nonpoint sources vary annually and spatially within the watershed, making them difficult to monitor. Furthermore, nonpoint sources are not regulated, and continued voluntary support from landowners and from state and federal permittee BMPs will help in mitigating impact.

Table 2.1. Characteristics of Subwatersheds in the Blacks Fork Watersheds

Subwatershed	Total Acreage	Percentage Agricultural	Percentage Urban	Percentage Shrub/Scrub and Grassland	Percentage Forest and Wetland	Point Sources	Nonpoint Sources	Total Current Load (giga colony forming unit/season)
Blacks Fork Drainage								
Blacks Fork Headwaters	121,375	0%	1%	22%	77%	None	Wildlife	9,349
Blacks Fork	15,839	32%	2%	35%	32%	None	Livestock, upstream	27,891
Fort Bridger	43,548	19%	3%	67%	11%	Fort Bridger Sewer District; Travel Centers of America	Livestock, wildlife	31,968
Lyman	26,735	26%	8%	54%	12%	Town of Lyman	Livestock, upstream, irrigation	49,290
Muddy Creek	617,330	0%	1%	91%	8%	None	Livestock, wildlife	209
Lower Blacks Fork	224,708	1%	1%	95%	3%	None	Livestock, wildlife	2,903
Smiths Fork Drainage								
Smiths Fork Headwaters	85,487	0%	1%	18%	81%	None	Wildlife	2,602
Upper Smiths Fork	50,709	31%	2%	46%	21%	None	Livestock	82,756
Smiths Fork	64,139	29%	3%	59%	9%	Town of Mountain View	Livestock, irrigation, upstream	144,814
Cottonwood Creek	83,714	0%	< 1%	80%	19%	None	Livestock, wildlife	100
Lower Smiths Fork	10,148	0%	< 1%	99%	0%	None	Upstream	92,697

The hydrologic regimes used in developing TMDLs for *E. coli* are based on the Blacks Fork Basin model and irrigation operations in the watershed. The Blacks Fork Basin model (see section 3.5.4.1 of the TMDL) provides estimates of monthly flow at various locations in the watershed for normal, wet, and dry hydrologic conditions. The impairment season, defined as May 1–September 30 (WDEQ 2013), was separated into three irrigation seasons based on local irrigation practices. According to the Uinta County Conservation District (UCCD), irrigation occurs early in the spring from May through June. Little to no irrigation occurs when hay is being cut, generally July through August. A second irrigation may occur in September and October if water is available.[1] As such, May and June are considered the spring loading season, whereas July and August are considered the summer loading season because this timeframe reflects summer thunderstorms and low flow with little influence from irrigation. The fall loading season (September) accounts for loading generated from storm events and any additional irrigation late in the growing season, but it is based on *E. coli* data collected in September and October because there were not enough data in September to characterize this condition. Hereafter, a *hydrologic regime* refers to a combination of the hydrologic condition (normal, wet, or dry) and irrigation season (spring, summer, or fall). Examples of hydrologic regimes are wet-spring, normal-summer, and dry-fall.

For the purposes of the implementation process, source loads and allocations from the normal climate condition will be used to identify necessary reductions and implementation measures. The normal climate condition was chosen because it was found to be protective of the wet and dry climate conditions and is the most likely condition to occur at 55% versus 24% and 21% of the dry and wet conditions, respectively. All of the *E. coli* loads discussed in this section are seasonal and represent the primary contact season for *E. coli* impairment (May 1–September 30).

Detailed methodology for generating current loads can be found in section 5 of the TMDL; however, an example of how these loads were calculated is shown below for the Fort Bridger subwatershed. The total load of 31,967 giga colony forming unit (G-cfu) per season (Table 2.2) is the sum of *E. coli* loads for the three seasons (spring, summer, and fall). These seasonal loads are the product of streamflow (liters/season) and the seasonal *E. coli* geomean (cfu/100 milliliters [mL]). Seasonal streamflow was taken from the hydrologic model produced by the Wyoming State Engineer's Office (see section 3.5.4.1 of the TMDL for a model description), and the E. *coli* geometric mean was determined from *E. coli* samples taken during relevant months in the Fort Bridger subwatershed. For the spring season (May/June), the calculation is as follows:

$$\text{20,410,424,006 liters of water/season} \times \text{61.12 cfu/100 mL} \times 10^{-8} \text{ (conversion factor to G-cfu/season)} = \text{12,475 G-cfu/season}$$

This same calculation was conducted for the summer (July and August) and fall (September) seasons for Fort Bridger, and all three loads were summed to obtain a total *E. coli* load for the entire impairment season (May–September). These calculations are as follows:

$$\text{4,343,089,559 liters of water/season} \times \text{364.70 cfu/100 mL} \times 10^{-8} \text{ (conversion factor to G-cfu/season)} = \text{15,839 G-cfu/season}$$

$$\text{1,094,098,392 liters of water/season} \times \text{333.87 cfu/100 mL} \times 10^{-8} \text{ (conversion factor to G-cfu/season)} = \text{3,653 G-cfu/season}$$

$$\text{12,457 G-cfu/spring season} + \text{15,839 G-cfu/summer season} + \text{3,653 G-cfu/fall season} = \text{31,967 G-cfu/impairment season}$$

[1] Personal communication. Technical Advisory Committee conference call between Erica Gaddis (SWCA) and Kerri Sabey (UCCD) regarding irrigation practices, August 29, 2013.

For the impairment season of a normal climate condition, compliance points (the most downstream point of each subwatershed in the impaired reach) in Reach 1 (Lyman, Fort Bridger) exhibit total loads of 49,290 and 31,967 G-cfu/season, respectively. Point sources comprise less than 1% of these loads, whereas livestock represent approximately 39% of the total load in Lyman and 81% of the total load in Fort Bridger. Upstream input accounts for 43% of the total load to Lyman and 5% of the total load in Fort Bridger. Diverted load in Lyman is 5,406 G-cfu/season and accounts for 11% of the total load. Septic contribution to total load in Lyman and Fort Bridger is comparatively less at approximately 3%.

Reach 3 (Lower Smiths Fork) has a total load of 92,697 G-cfu/season with a 0% contribution from point sources. The largest input enters the reach from upstream and accounts for 83% of the total load in the amount of 76,602 G-cfu/season. Livestock account for 14% and wildlife for approximately 3% of the total load.

Compliance points in Reach 4 (Upper Smiths Fork, Smiths Fork) exhibit total loads of 82,756 and 144,814 G-cfu/season, respectively, less than 1% of which is from point sources (see Table 2.2). Livestock contribute the largest loads of 76,022 and 85,512 G-cfu/season representing 92% and 59% of the total load, respectively. Wildlife sources account for 4%–5%, whereas septics account for 2% at both compliance points. In the Smiths Fork subwatershed, diverted load accounts for 13% of the total load.

For contributing tributaries (Blacks Fork Headwaters, Blacks Fork, and Cottonwood Creek), livestock and wildlife consistently contribute the largest amount of *E. coli*.

Table 2.2. Source Loads (G-cfu) Calculated for each Subwatershed for the Normal Climate Condition During the Impairment Season (May–September)

Impaired Reach	Compliance Point	Upstream	Diverted	Septic	Pet Waste	Wildlife	Livestock	Total Nonpoint Source	Point Source	Total
1	Lyman	21,395	5,406	992	493	1,437	19,321	49,045	245	49,290
	Fort Bridger	1,586	–	1,157	309	2,900	25,960	31,913	55	31,967
3	Lower Smiths Fork	76,602	–	–	5	2,934	13,156	92,697	–	92,697
4	Upper Smiths Fork	–	–	1,892	180	4,662	76,022	82,756	–	82,756
	Smiths Fork	31,492	19,196	2,178	644	5,668	85,512	144,691	123	144,814
Contributing Tributaries	Blacks Fork Headwaters	–	–	64	14	5,530	3,742	9,349	–	9,349
	Blacks Fork	3,804	–	161	22	833	23,071	27,891	–	27,891
	Cottonwood Creek	0	–	0	0	27	73	100	–	100

2.1.1. Point Sources

Point sources of bacteria affect year-round water quality in the Blacks Fork Watershed at a relatively low and constant rate. During periods of low flow, point sources tend to represent a larger portion of the total load to streams. Four regulated point sources in the watershed discharge bacteria under individual Wyoming Pollutant Discharge Elimination System (WYPDES) permits (Figure 2.1) (WDEQ 2014). Point source outfalls were identified through WYPDES permits and are in the Fort Bridger, Lyman, and Smiths Fork subwatersheds. All data were obtained from discharge monitoring reports, which are used as regulatory tools by the WYPDES program to monitor discharge and ensure permit compliance.

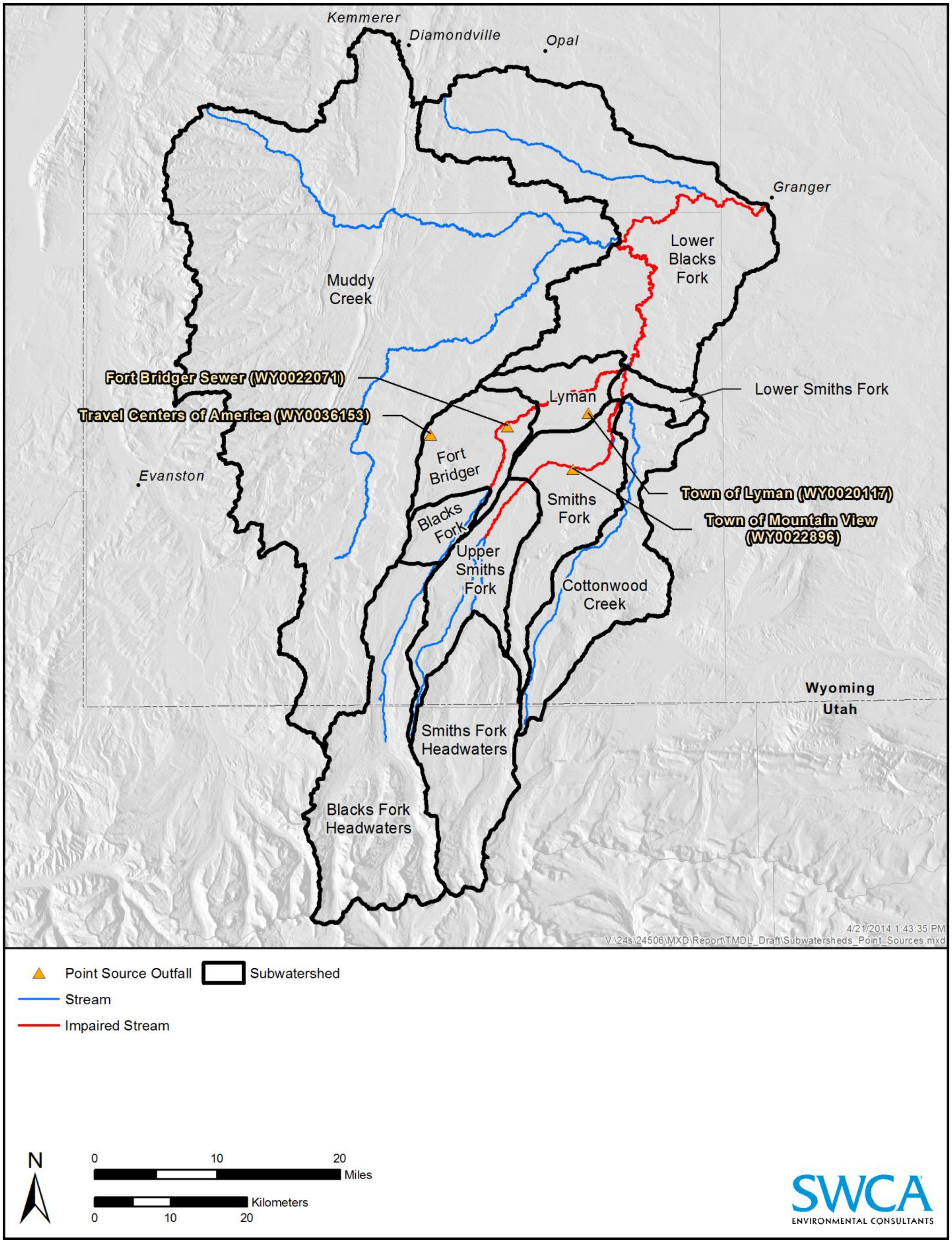

Figure 2.1. Four point source outfalls in the Blacks Fork Watershed.

2.1.1.1. FORT BRIDGER SEWER

The Fort Bridger Sewer District operates wastewater lagoons that service 165 connections in the town of Fort Bridger. Wastewater is discharged to an unnamed drainage ditch that is tributary to the Blacks Fork River in the Fort Bridger subwatershed. Typically, irrigation flows or precipitation are needed to transport effluent to the river. The lagoons include an aerated cell followed by a non-aerated cell with chlorination used for disinfection. The facility currently treats 0.14 million gallons per day (MGD), with a design capacity of 0.30 MGD and a permitted *E. coli* concentration of 126 cfu/100 milliliters (mL). Discharge monitoring data and operational details for this facility were provided by the WDEQ and include monthly geometric mean (geomean) values for *E. coli* from 2003 through 2011. The current permit, WYPDES WY0022071, was issued on January 18, 2012. The treatment plant typically operates well below the permitted *E. coli* load under all climate conditions and has exhibited only two *E. coli* concentration exceedances since 2003. In June 2006, the reported concentration was 380 cfu/100 mL and in April 2010, the concentration peaked at 1,534 cfu/100 mL.

2.1.1.2. TOWN OF LYMAN

The Lyman Wastewater Lagoon serves the town of Lyman in Uinta County, Wyoming. The facility has a design capacity of 0.495 MGD and a permitted *E. coli* concentration of 126 cfu/100 mL. It consists of a three-cell lagoon system, in which the first two cells are aerated. Wastewater passes through a chlorine contact chamber before discharging into Lyman Draw via an unnamed ephemeral tributary to the Blacks Fork River in the Lyman subwatershed. Discharge monitoring data for this facility and operational details were provided by the WDEQ and include monthly geomean values for *E. coli* from 2003 through 2011.The current permit, WYPDES WY0020117, was issued on August 31, 2012. Discharge monitoring report (DMR) data show that Lyman has discharged effluent with concentrations above what is permitted. For six of the nine hydrologic regimes, average *E. coli* concentrations are above 126 cfu/100 mL, with the highest average value of 483 cfu/100 mL occurring during a summer-dry regime. The Lyman Wastewater Lagoon is working with the WDEQ to mitigate effluent *E. coli* concentrations, which exceed the permitted allowance. Doing so will be necessary to comply with the wasteload allocation (WLA).

2.1.1.3. TOWN OF MOUNTAIN VIEW

The Mountain View Wastewater Lagoon in the Smiths Fork subwatershed serves a population of 1,286 people (U.S. Census Bureau 2010) in the town of Mountain View, Wyoming. The facility previously consisted of a three-cell lagoon system in which the first two cells were aerated with SolarBees and chlorination treatment was employed. In August 2012, a new facility was constructed with a design capacity of 0.34 MGD and a permitted *E. coli* concentration of 126 cfu/100mL; here, wastewater flows through automatically operated coarse screening and then to an anaerobic treatment cell followed by complete and partial mix cells and a settling cell. Effluent then flows to a submerged aerated growth reactor. Lastly, the effluent is chlorinated, dechlorinated, and discharged directly into Smiths Fork River. Discharge monitoring data and operational details for this facility were provided by the WDEQ and include monthly averages for *E. coli* from 2003 through 2011. Available data since construction of the new plant (September 2012–December 2013) show monthly average *E. coli* concentrations that range from 1 cfu/100 mL to 980 cfu/100 mL. The current permit, WYPDES WY0022896, was issued on October 2, 2013. The source identification calculations are based on the full data set from 2003 to 2011 to match with the available water quality data used in the analysis. Recent upgrades to the Mountain View Wastewater Lagoon system are reflected in the implementation plan for the watershed.

2.1.1.4. TRAVEL CENTERS OF AMERICA

Travel Centers of America is a truck stop/refueling plaza off Interstate 80 near the town of Fort Bridger, Wyoming. The facility is not connected to any municipal wastewater treatment system; however, it does consist of a three-cell stabilization pond system with an aerated first cell and tablet chlorination following the second cell. Treated effluent flows into a human-made contained wetland that is not tributary to any other surface waters. Although the facility has not discharged since April 2005, it is included as a point source because it is in the Fort Bridger subwatershed and has the potential to affect historical loads. The current permit, WYPDES WY0036153, was issued on November 1, 2010.

2.1.1.5. SUMMARY OF POINT SOURCE LOAD

Across all hydrologic regimes, point source loads are generally small, remaining under 200 G-cfu/season (Figure 2.2, Table 2.3). A season is defined as a 60-day period in spring, summer, or fall. The towns of Mountain View and Lyman typically discharge higher loads than Fort Bridger, with Mountain View exhibiting peak discharge loads in spring and fall of a wet climate year due to high *E. coli* concentrations. When compared to total loads, Fort Bridger and Smiths Fork subwatersheds contribute negligibly, with only a 2% maximum contribution. Loads in the Lyman subwatershed are comparatively higher, contributing up to 5% of the total load during the dry-fall hydrologic regime.

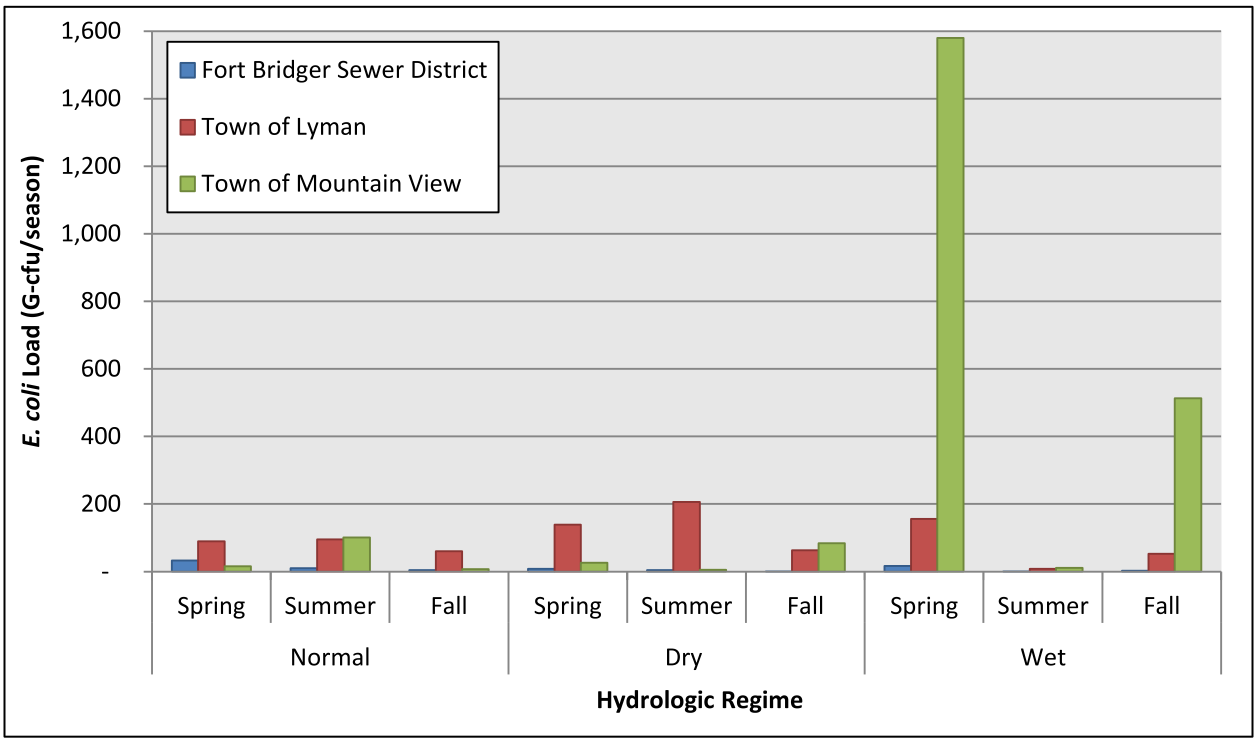

Figure 2.2. Seasonal point source loads from the three wastewater treatment plants in the Blacks Fork Watershed.

Table 2.3. Point Source Loads (G-cfu/season) in the Fort Bridger, Lyman, and Smiths Fork Subwatersheds during the Nine Hydrologic Regimes

Hydrologic Regime		Subwatershed		
Climate	**Season**	**Fort Bridger**	**Lyman**	**Smiths Fork**
Normal	Spring	35	90	15
	Summer	13	95	101
	Fall	6	60	7
Dry	Spring	11	139	26
	Summer	7	206	5
	Fall	2	63	84
Wet	Spring	20	156	1,579
	Summer	4	8	11
	Fall	4	52	513

2.1.2. Nonpoint Sources

Nonpoint source pollution originates from many diffuse sources across the landscape. In the Blacks Fork Watershed, nonpoint sources include agricultural practices such as livestock grazing and irrigation on both public and private land, wildlife, septic systems, and pet waste. Restoring water quality and protecting beneficial uses will benefit from describing and addressing each of these sources individually and applying an appropriate set of implementation measures. Nonpoint sources are not regulated; therefore, all efforts to reduce nonpoint source contribution are voluntary. The following nonpoint source load descriptions are based on seasonal loads occurring during the impairment season (May–September), which are further differentiated into nine hydrologic regimes. *E. coli* load production from livestock, wildlife, septic systems, and pet waste was generated using the bacteria source load calculator (BSLC), a detailed description of which can be found in Appendix A of the *Blacks Fork Watershed Total Maximum Daily Loads Report* (SWCA 2014).

2.1.2.1. IRRIGATION

Irrigation practices are widespread throughout the Blacks Fork Watershed (Figure 2.3). There are over 380 points of diversion and approximately 217,720 linear feet of irrigation canals and ditches. This extensive canal network transfers water from Blacks Fork to Upper Smiths Fork via the Bridger Joint Power pipeline, and from Blacks Fork, Lyman, and Fort Bridger subwatersheds to Smiths Fork. There are also interwatershed transfers occurring in Blacks Fork, Lyman, and Fort Bridger subwatersheds. Although only 6% of the total watershed acreage is irrigated, most of the subwatersheds that are impaired for *E. coli* exhibit anywhere from 24% to 50% irrigated acreage (Table 2.4). Subirrigated acreage is also included in this estimate and is defined by the Wyoming Water Development Office as lands that appear to be receiving irrigation water (based on aerial imagery analysis) but have no appropriated water right. Flood irrigation allows water to flow from a ditch or stream onto the fields directly through a headgate or other diverting works. This method has the potential to flush soil, biomass, manure, and fertilizer off the field and into the ditch or stream. Furthermore, *E. coli* monitoring of selected irrigation canals conducted in September 2013 revealed concentrations ranging from 866 to 1,986 cfu/100 mL. Given these high concentrations and the complexity of irrigation flows throughout the landscape, determining the amount of *E. coli* lost or gained through irrigation diversions and returns is an important component of this TMDL process.

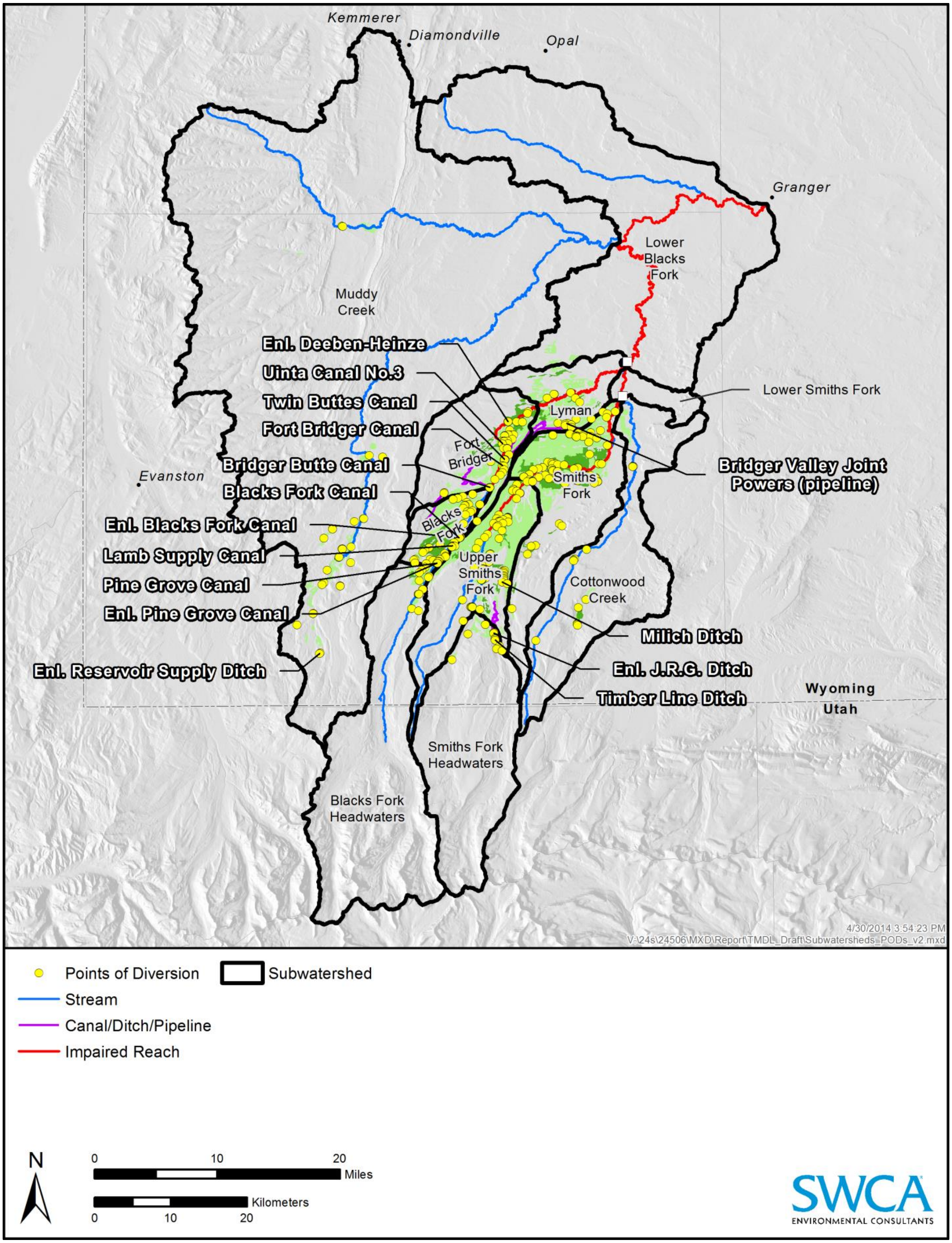

Figure 2.3. Basin-wide location of irrigation canals and points of diversion.

Table 2.4. Percentage of Irrigated and Subirrigated Lands

Subwatershed	Percentage Irrigated	Percentage Subirrigated	Total Irrigated
Blacks Fork Headwaters	1%	<1%	1%
Blacks Fork	33%	17%	50%
Fort Bridger	19%	5%	24%
Lyman	28%	4%	31%
Smiths Fork Headwaters	1%	0%	1%
Upper Smiths Fork	37%	3%	40%
Smiths Fork	22%	10%	32%
Cottonwood Creek	2%	<1%	2%
Lower Smiths Fork	0%	0%	0%
Muddy Creek	<1%	0%	<1%
Lower Blacks Fork	<1%	0%	<1%

Note: Subirrigated lands receive irrigation water but have no appropriated water right (Wyoming Water Development Office 2003).

An irrigation load was calculated for each of the 11 subwatersheds and incorporated into the overall load analysis. Irrigation loads were generated by identifying model nodes in each subwatershed where irrigation diversions or returns were occurring. Diverted and return flows were summed, resulting in a net irrigation flow for each node. The node was then assigned a water quality station or in some cases, an average of two water quality stations where a geomean was calculated using all available *E. coli* data for that hydrologic regime. Diversion flows were assigned water quality stations closest to the point of delivery, whereas return flows were assigned water quality stations from the origin of the diversion. The *E. coli* geomean was multiplied by the net irrigation flow to obtain a load. Irrigation loads were summed by subwatershed to create a seasonal irrigation load for each climate condition. Negative diverted loads indicate a net return of *E. coli* to the subwatershed.

Irrigation loads are presented in Table 2.5 by hydrologic regime. Blacks Fork, Fort Bridger, and Upper Smiths Fork exhibit fairly large net losses of *E. coli* loads through diversions. Contrastingly, Lyman and Smiths Fork subwatersheds exhibit a net gain of *E. coli* because of irrigation returns.

Table 2.5. Irrigation Loads (G-cfu/season) for each Subwatershed during the Nine Hydrologic Regimes

Hydrologic Regime		Subwatershed										
Climate	Season	Blacks Fork Headwaters	Blacks Fork	Fort Bridger	Lyman	Smiths Fork Headwaters	Upper Smiths Fork	Smiths Fork	Cottonwood Creek	Lower Smiths Fork	Muddy Creek	Lower Blacks Fork
Normal	Spring	–	877	6,673	-1,266	–	8,745	-1,290	10	–	–	163
	Summer	–	3,507	21,869	-3,805	–	2,700	-15,307	–	–	–	86
	Fall	–	584	2,041	-334	–	656	-2,599	–	–	–	13

Table 2.5. Irrigation Loads (G-cfu/season) for each Subwatershed during the Nine Hydrologic Regimes

Hydrologic Regime		Subwatershed										
Climate	**Season**	**Blacks Fork Headwaters**	**Blacks Fork**	**Fort Bridger**	**Lyman**	**Smiths Fork Headwaters**	**Upper Smiths Fork**	**Smiths Fork**	**Cottonwood Creek**	**Lower Smiths Fork**	**Muddy Creek**	**Lower Blacks Fork**
Dry	Spring	–	758	6,310	-445	–	10,200	-2,047	11	–	–	1,508
	Summer	–	2,887	2,231	-3,708	–	4,651	-7,494	–	–	–	33
	Fall	–	371	811	-735	–	1,390	-1,826	–	–	–	12
Wet	Spring	–	2,349	1,620	-540	–	8,530	-1,532	9	–	–	–
	Summer	–	3,679	24,052	-3,135	–	16,057	-6,915	–	–	–	103
	Fall	–	760	1,769	-878	–	2,510	-2,505	–	–	–	29

Note: Negative numbers indicate a net return or delivery of *E. coli* to the subwatershed; positive numbers indicate a net loss of *E. coli* from the subwatershed.

2.1.2.2. UPSTREAM

Accurately quantifying the loading of *E. coli* from activities in each subwatershed requires accounting for the load entering the subwatershed from upstream. A subwatershed with a proportionally large upstream load indicates that *E. coli* is not necessarily originating in the landscape but is being sourced from upstream. Upstream loads for each subwatershed during the nine hydrologic regimes are presented in Table 2.6. These loads were calculated taking into account *E. coli* population variations during surface water transit (see section 4.2.2.1 of the TMDL report). When compared to total load during a normal climate condition, upstream loads to Lyman, Smiths Fork, and Lower Smiths Fork subwatersheds can contribute a large portion depending on the season (Figure 2.4). The upstream load in Lower Smiths Fork is consistently above 60% of the total load across all seasons and can be as high as 90% of the total load during the summer and fall.

Table 2.6. Seasonal Upstream Loads (G-cfu/season) for the Nine Hydrologic Regimes: Normal, Dry, and Wet Climate Conditions

Hydrologic Regime		Subwatershed										
Climate	**Season**	**Blacks Fork Headwaters**	**Blacks Fork**	**Fort Bridger**	**Lyman**	**Smiths Fork Headwaters**	**Upper Smiths Fork**	**Smiths Fork**	**Cottonwood Creek**	**Lower Smiths Fork**	**Muddy Creek**	**Lower Blacks Fork**
Normal	Spring	–	803	1,106	9,805	–	–	23,823	–	27,887	–	1,095
	Summer	–	2,683	-	10,429	–	–	5,390	–	2,175	–	183
	Fall	–	317	480	1,161	–	–	2,279	–	6,540	–	28
Dry	Spring	–	511	1,267	3,094	–	–	9,114	–	13,147	–	3,121
	Summer	–	1,734	1,478	909	–	–	3,347	–	20,879	–	91

Table 2.6. Seasonal Upstream Loads (G-cfu/season) for the Nine Hydrologic Regimes: Normal, Dry, and Wet Climate Conditions

Hydrologic Regime		**Subwatershed**										
Climate	**Season**	**Blacks Fork Headwaters**	**Blacks Fork**	**Fort Bridger**	**Lyman**	**Smiths Fork Headwaters**	**Upper Smiths Fork**	**Smiths Fork**	**Cottonwood Creek**	**Lower Smiths Fork**	**Muddy Creek**	**Lower Blacks Fork**
	Fall	–	132	383	202	–	–	1,388	–	5,688	–	40
Wet	Spring	–	3,047	11,374	12,090	–	52	51,934	–	71,381	–	1,977
	Summer	–	4,382	37,380	30,977	–	–	29,147	–	38,485	–	456
	Fall	–	642	5,099	5,098	–	–	5,557	–	29,111	–	93

Note: Loads include survival rate.

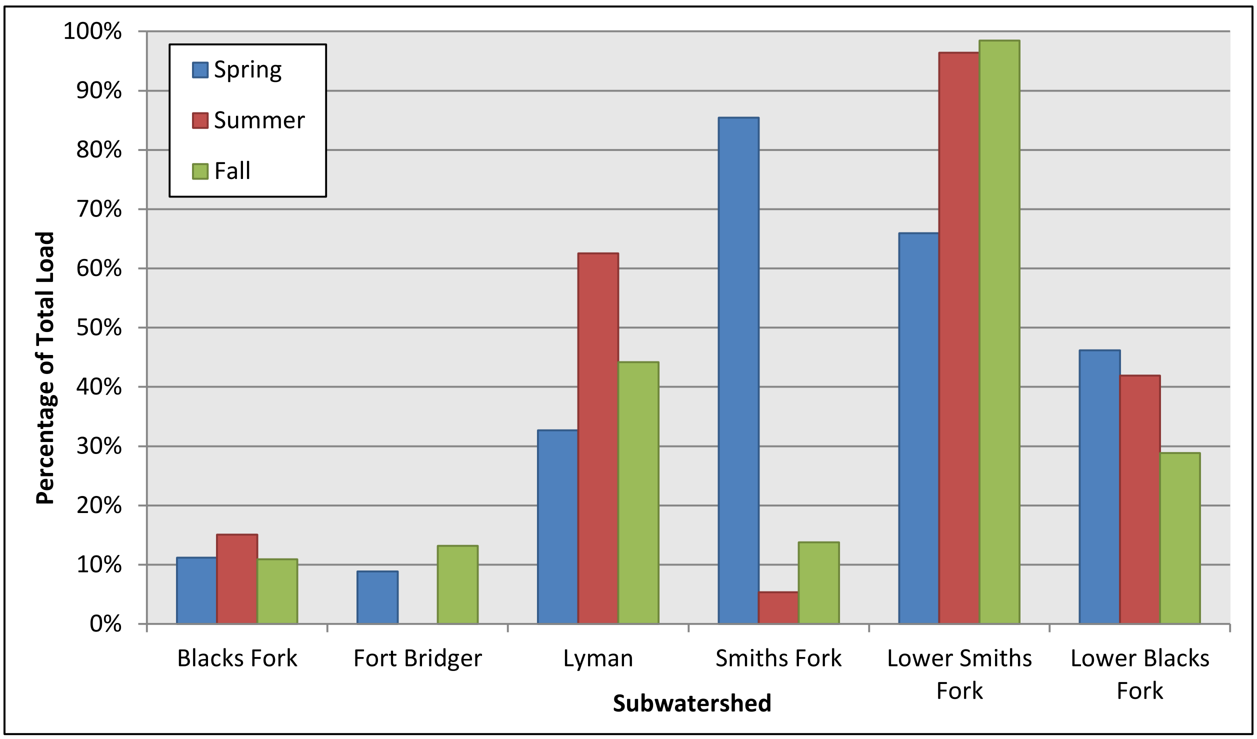

Figure 2.4. Seasonal upstream loads as a percentage of total load in subwatersheds during the normal climate condition.

2.1.2.3. WATERSHED

Calculated point source, irrigation, and upstream loads were summed and subtracted from current loads to determine a watershed load for each subwatershed (Table 2.7). These watershed loads represent the sum of *E. coli* input from nonpoint sources that include livestock, wildlife, septic systems, and pet waste. Figure 2.5 provides a visual of the proportional contribution of watershed loads to total loads and clearly illustrates the importance of watershed load to impairments during a normal climate condition. Watershed loads were further quantified using the BSLC to determine specific loads from livestock, wildlife, septic systems, and pet waste, all of which will be discussed in detail below. The BSLC modeling methodology can be found in Appendix A of the TMDL report (SWCA 2014).

Table 2.7. Watershed Loads (G-cfu/season) for each Subwatershed during the Nine Hydrologic Regimes

Hydrologic Regime		Subwatershed										
Climate	**Season**	**Blacks Fork Headwaters**	**Blacks Fork**	**Fort Bridger**	**Lyman**	**Smiths Fork Headwaters**	**Upper Smiths Fork**	**Smiths Fork**	**Cottonwood Creek**	**Lower Smiths Fork**	**Muddy Creek**	**Lower Blacks Fork**
Normal	Spring	1,783	6,383	11,333	18,821	605	72,297	2,760	80	14,419	188	1,276
	Summer	6,611	15,118	15,828	2,350	1,724	7,451	79,556	16	1,575	18	253
	Fall	955	2,587	3,164	1,072	273	3,008	11,687	4	101	3	68
Dry	Spring	1,316	8,698	2,833	3,594	328	13,743	6,932	18	299	16	12,612
	Summer	5,012	13,187	157	0	1,223	5,034	16,538	3	836	4	149
	Fall	532	1,881	51	236	125	1,731	2,390	1	1,503	2	39
Wet	Spring	5,901	11,841	2,878	32,456	2,917	65,544	26,106	200	4,746	432	11,201
	Summer	8,644	80,345	12,873	16,558	3,092	80,169	2,412	50	70,667	41	3,257
	Fall	1,489	8,892	1,563	4,598	554	7,473	25,417	10	1,373	13	600

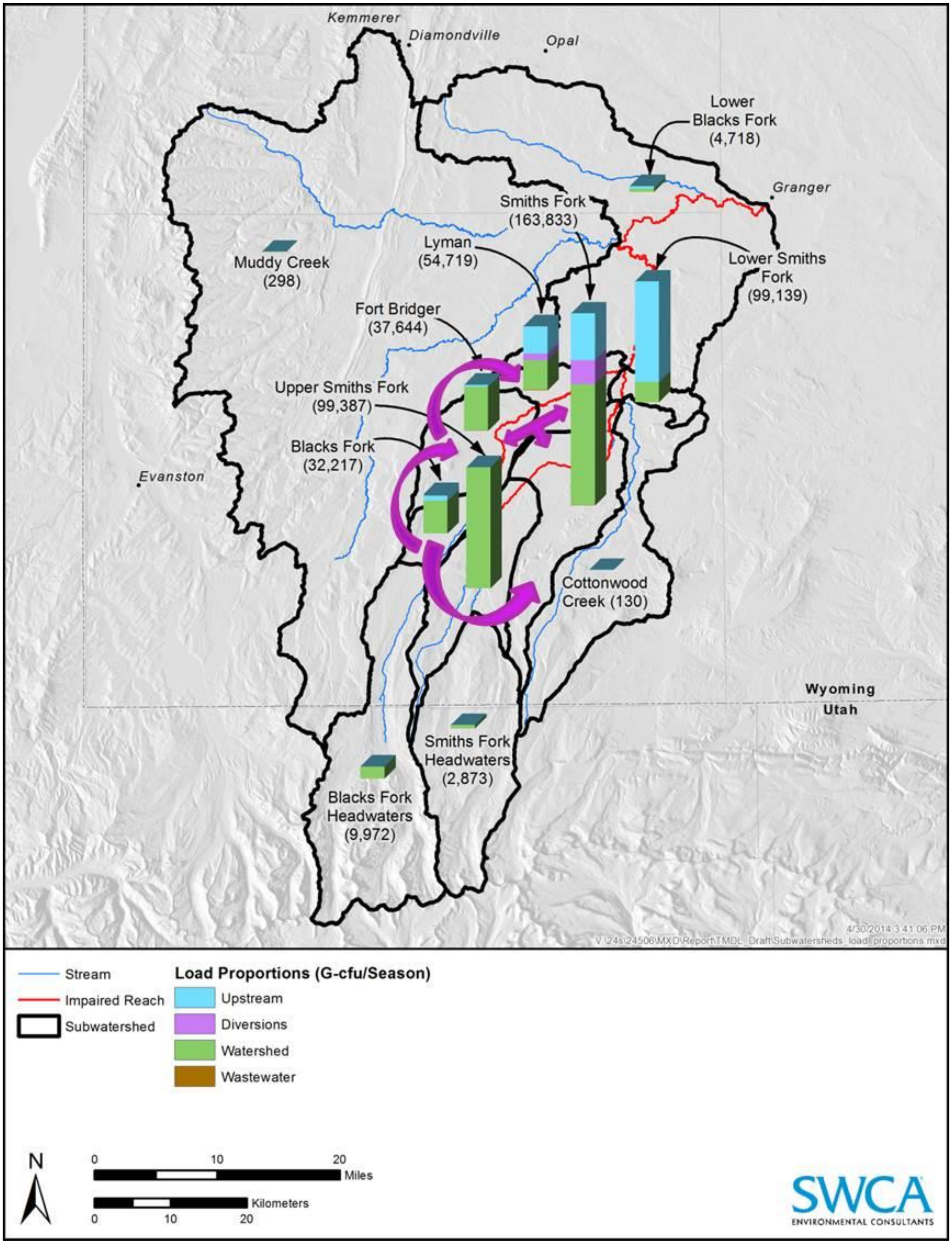

Figure 2.5. Load proportions for each subwatershed during the normal climate condition. Arrows indicate transfer of water between subwatersheds via irrigation infrastructure and are not drawn to scale.

2.1.2.3.1. Livestock

Livestock grazing is present throughout the Blacks Fork Watershed, with grazing occurring on both public and private lands. BLM, USFS, and state grazing allotment acreage accounts for approximately 88% of the total watershed acreage, with many subwatersheds exhibiting higher percentages (Figure 2.6). Livestock estimates using agricultural census data reveal that 46,461 animal units reside in the watershed, 80% of which are cattle and 15% of which are sheep (Figure 2.7). *Animal units* are defined by the BLM as a unit of measure for rangeland livestock equivalent to one mature cow, which typically consumes an average of 26 pounds of dry matter per day (BLM 2011). Converting livestock numbers to animal units required the use of an animal unit equivalent (AUE) conversion factor. For cows, AUE is 1; for sheep, AUE is 0.21; for horses, AUE is 1.25; and for goats, AUE is 0.15 (Pratt and Rasmussen 2001). The number of animals residing in the watershed coupled with complex grazing patterns contributes to the *E. coli* loads from livestock in most subwatersheds across all hydrologic regimes (Table 2.8). Cattle are primarily housed in the inner-basin subwatersheds in the winter and early spring, and are then moved to outer regions in the summer and fall. A small portion of cattle is transferred to USFS allotments in the headwaters, whereas others are moved to regions beyond the watershed boundary.

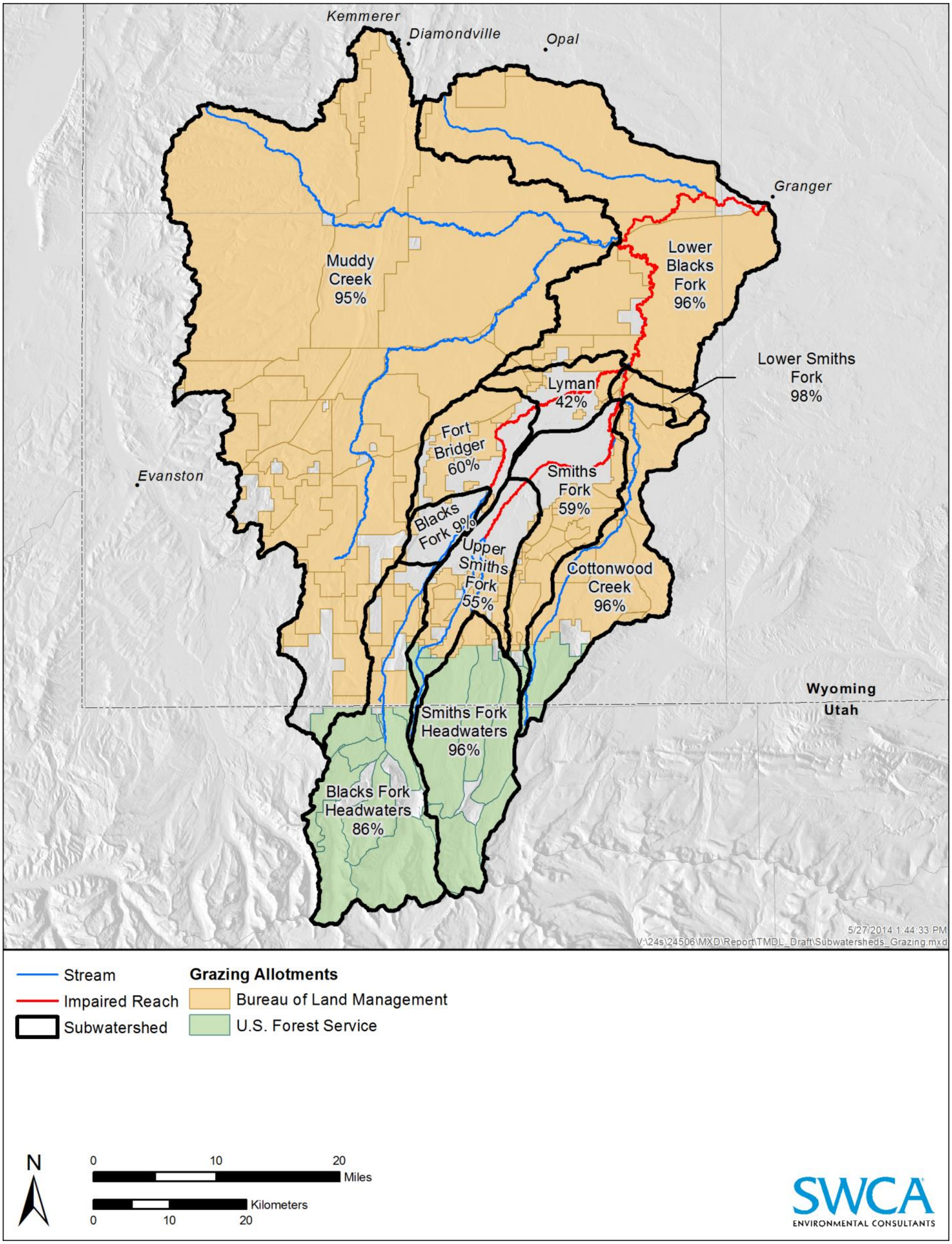

Figure 2.6. Publicly administered grazing allotments by subwatershed with percentage of total acreage.

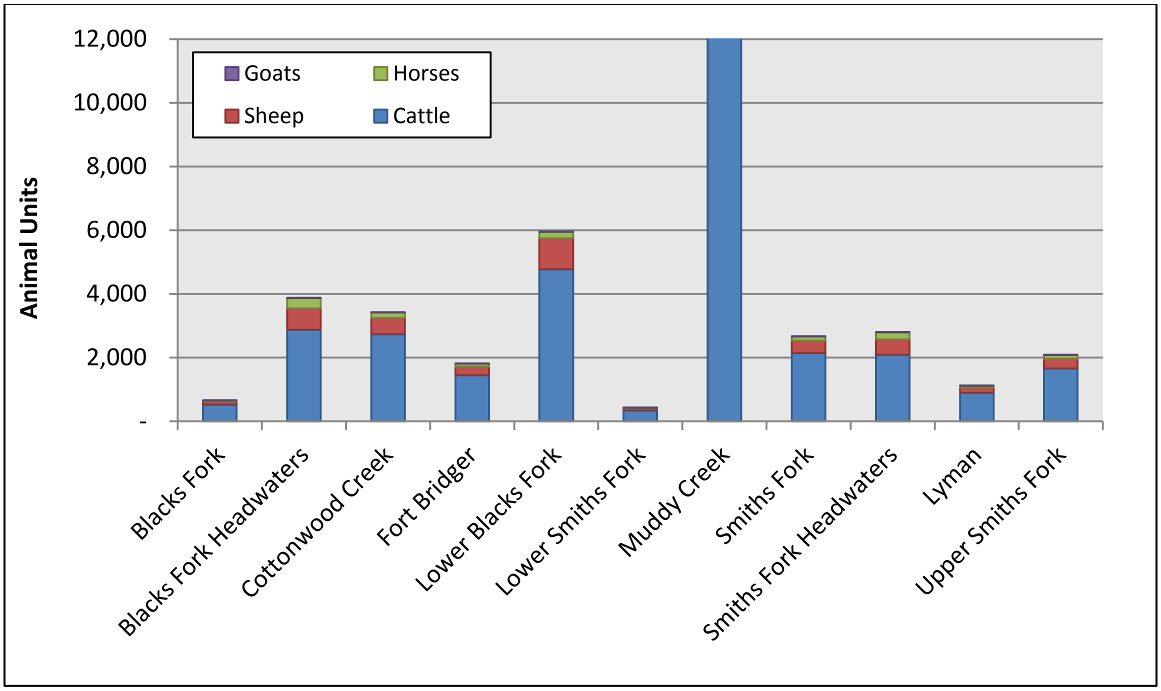

Figure 2.7. Animal units by species for each subwatershed.

Table 2.8. Livestock Loads (G-cfu/season) for each Subwatershed during the Nine Hydrologic Regimes

Hydrologic Regime		Subwatershed										
Climate	Season	Blacks Fork Headwaters	Blacks Fork	Fort Bridger	Lyman	Smiths Fork Headwaters	Upper Smiths Fork	Smiths Fork	Cottonwood Creek	Lower Smiths Fork	Muddy Creek	Lower Blacks Fork
Normal	Spring	303	6,114	10,249	16,770	123	66,828	2,541	59	11,971	162	966
	Summer	3,302	14,480	13,079	1,750	742	6,543	72,331	12	1,114	14	141
	Fall	136	2,477	2,632	801	122	2,652	10,641	4	71	2	40
Dry	Spring	224	8,331	2,562	3,202	67	12,703	6,381	13	248	14	9,549
	Summer	2,503	12,631	130	0	526	4,420	15,036	2	591	3	83
	Fall	76	1,802	42	177	56	1,526	2,176	1	1,062	2	23
Wet	Spring	1,004	11,342	2,603	28,918	593	60,586	24,031	147	3,940	371	8,480
	Summer	4,318	76,956	10,636	12,329	1,331	70,395	2,193	36	49,976	32	1,822
	Fall	213	8,517	1,299	3,436	247	6,588	23,142	10	970	10	357

2.1.2.3.2. Wildlife

Wildlife are abundant in the Blacks Fork Watershed, with antelope, deer, elk, and moose claiming some portion of the watershed as habitat range throughout the year. Wildlife contribution to *E. coli* loading is a result of direct defecation into streams or runoff from the surrounding landscape. A population estimate of wildlife by subwatershed reveals that deer, elk, and moose tend to occupy the headwaters and Muddy

Creek subwatersheds, whereas antelope are more prevalent in the lowlands (Table 2.9). A wildlife density analysis was also conducted for all four species; this analysis shows that the highest wildlife densities are in the center of the basin and consist primarily of deer and antelope (Figure 2.8). Additionally, seasonality was explored using habitat range maps intersected with the subwatersheds (Figure 2.9). In general, the inner-basin subwatersheds exhibit higher wildlife populations in the winter months when snow and severe weather push animals to lower elevations. Contrastingly, headwater regions see higher populations during the summer as mostly elk and deer move to higher grounds (Table 2.10). As a result of these seasonal movements, *E. coli* loading from wildlife is most significant in the Blacks Fork Headwaters and Smiths Fork Headwaters subwatersheds across all hydrologic regimes (Table 2.11). Waterfowl was also explored as an additional source using the BSLC and was found to contribute < 1% of the total load (see Appendix A, section 1.3.1).

Table 2.9. Population Estimates for each Subwatershed for Deer, Elk, Moose, and Antelope

Subwatershed	Deer	Elk	Moose	Antelope
Blacks Fork	145	20	2	111
Blacks Fork Headwaters	1,565	598	52	208
Cottonwood Creek	777	112	9	577
Fort Bridger	400	56	6	263
Lower Blacks Fork	127	315	47	690
Lower Smiths Fork	92	13	1	71
Muddy Creek	3,044	878	120	2,248
Smiths Fork	589	80	7	451
Smiths Fork Headwaters	1,079	397	34	181
Lyman	146	36	4	126
Upper Smiths Fork	470	67	6	351
Total	8,434	2,572	288	5,277

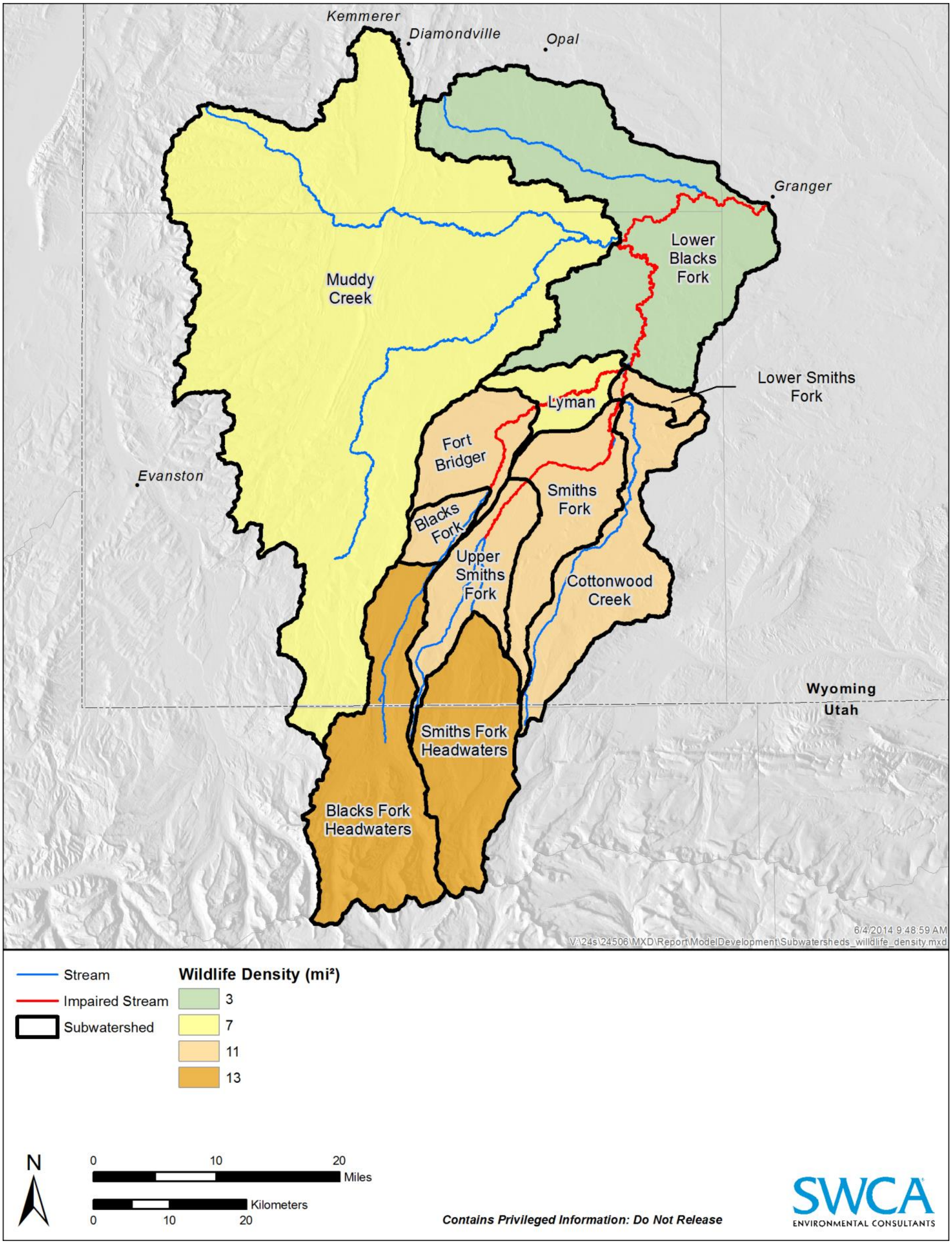

Figure 2.8. Maximum wildlife density expressed as number of animals per square mile for each subwatershed.

Table 2.10. Total Monthly Wildlife Populations for each Subwatershed for Moose, Elk, Deer, and Antelope

Subwatershed	January	February	March	April	May	June	July	August	September	October	November	December
Blacks Fork	278	278	278	278	111	111	111	111	111	111	111	278
Blacks Fork Headwaters	2,215	2,215	2,215	2,215	2,423	2,423	2,423	2,423	2,423	2,423	2,423	2,215
Cottonwood Creek	1,475	1,475	1,475	1,475	1,466	1,466	1,466	1,466	1,466	1,466	1,466	1,475
Fort Bridger	725	725	725	725	263	263	263	263	263	263	263	725
Lower Blacks Fork	1,179	1,179	1,179	1,179	864	864	864	864	864	864	864	1,179
Lower Smiths Fork	177	177	177	177	71	71	71	71	71	71	71	177
Muddy Creek	6,290	6,290	6,290	6,290	6,290	6,290	6,290	6,290	6,290	6,290	6,290	6,290
Smiths Fork	1,127	1,127	1,127	1,127	451	451	451	451	451	451	451	1,127
Smiths Fork Headwaters	1,691	1,691	1,691	1,691	1,691	1,691	1,691	1,510	1,510	1,510	1,510	1,510
Lyman	312	312	312	312	126	126	126	126	126	126	126	312
Upper Smiths Fork	893	893	893	893	821	821	821	821	821	821	821	893

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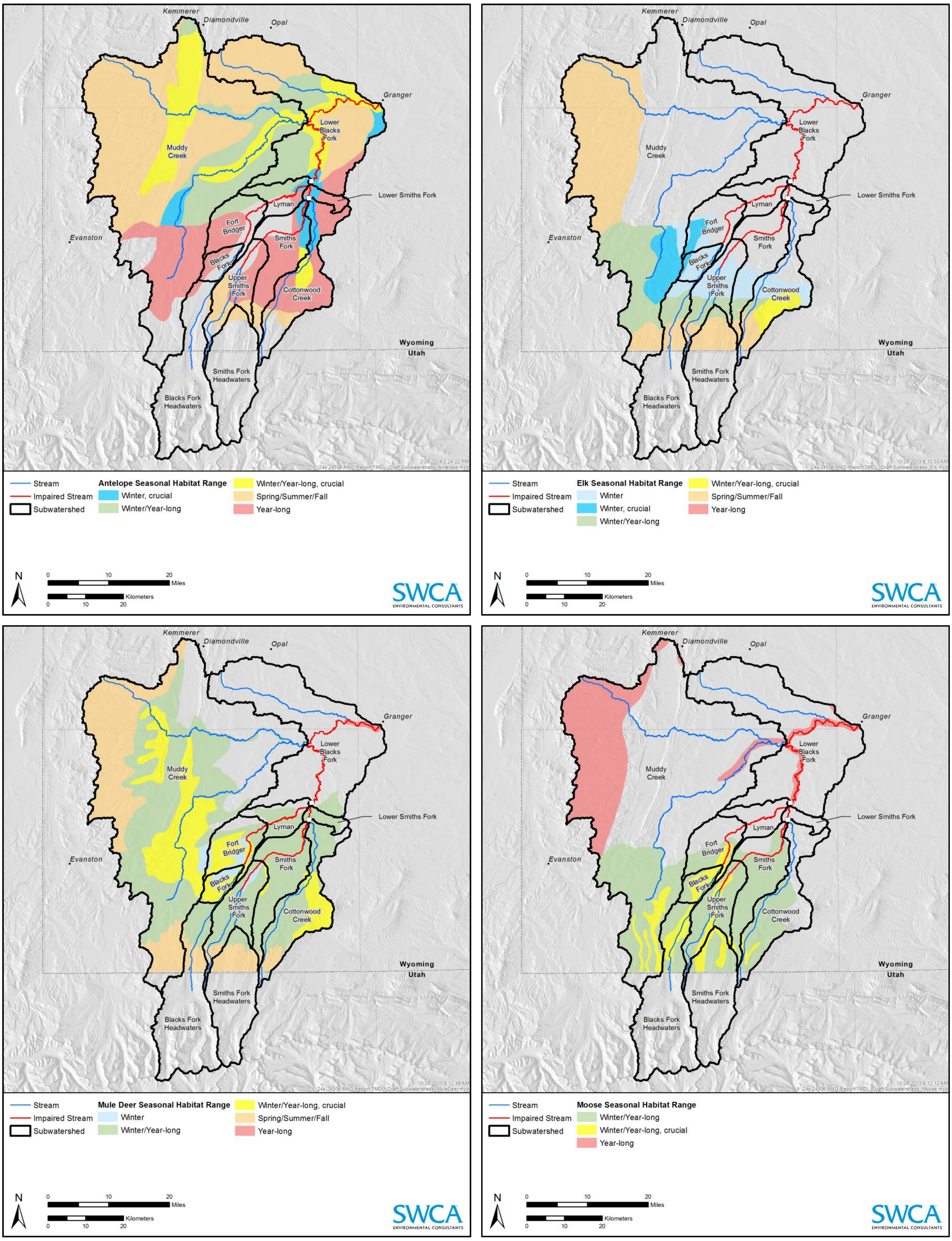

Figure 2.9. Habitat ranges for antelope, elk, mule deer, and moose in each subwatershed.

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Table 2.11. Wildlife Loads (G-cfu/season) for each Subwatershed during the Nine Hydrologic Regimes

Hydrologic Regime		Subwatershed										
Climate	Season	Blacks Fork Headwaters	Blacks Fork	Fort Bridger	Lyman	Smiths Fork Headwaters	Upper Smiths Fork	Smiths Fork	Cottonwood Creek	Lower Smiths Fork	Muddy Creek	Lower Blacks Fork
Normal	Spring	1,459	221	720	1,009	481	3,786	146	21	2,444	26	309
	Summer	3,263	523	1,826	295	979	629	4,824	4	460	4	111
	Fall	807	89	354	133	151	247	698	1	30	1	27
Dry	Spring	1,077	301	180	193	261	720	368	5	51	2	3,056
	Summer	2,474	456	18	0	695	425	1,003	1	244	1	66
	Fall	450	65	6	29	69	142	143	0	440	0	16
Wet	Spring	4,829	409	182	1,740	2,317	3,432	1,385	53	804	61	2,714
	Summer	4,267	2,778	1,485	2,080	1,756	6,766	146	14	20,655	9	1,432
	Fall	1,259	307	175	571	306	613	1,519	3	402	3	242

2.1.2.3.3. Septics

Septic systems have the potential to contribute pathogens to waterways by means of failures, malfunctions, improper design, poor site location, or direct pipe discharge to a stream. Systems that are functioning properly treat wastewater by means of an underground leach field that removes pathogens by filtering, adsorption, natural die-off, and other biochemical processes. Problems arise when leach fields fail or interact with shallow groundwater, causing wastewater to reach a stream without proper treatment.

Identifying septic contribution to pathogen loading requires estimating the number of septic systems in each subwatershed and understanding their position in the landscape, particularly with regard to irrigation practices (see section 4.2.3.3 of the TMDL). Fort Bridger, Smiths Fork, Upper Smiths Fork, and Lyman subwatersheds have the highest number and density of septics in the Blacks Fork Watershed (Table 2.12). The number and density of septics translate to high *E. coli* load contribution to surface waters particularly during a wet climate condition (Table 2.13). There is also a large number of septics in an irrigated landscape (Figure 2.10) that can further increase the likelihood of septic contribution through leach field flushing.

Table 2.12. Total Septic Systems and Septic System Density for each Subwatershed

Subwatershed	Total Septics	Density (number/square mile)
Blacks Fork	48	2
Blacks Fork Headwaters	123	1
Cottonwood Creek	4	< 1
Fort Bridger	375	6
Lower Blacks Fork	13	< 1
Lower Smiths Fork	2	< 1
Muddy Creek	56	< 1
Smiths Fork	349	3
Smiths Fork Headwaters	17	< 1
Lyman	335	8
Upper Smiths Fork	232	3

Table 2.13. Loads (G-cfu/season) from Septic Systems for each Subwatershed during the Nine Hydrologic Regimes

Hydrologic Regime		Subwatershed										
Climate	**Season**	**Blacks Fork Headwaters**	**Blacks Fork**	**Fort Bridger**	**Lyman**	**Smiths Fork Headwaters**	**Upper Smiths Fork**	**Smiths Fork**	**Cottonwood Creek**	**Lower Smiths Fork**	**Muddy Creek**	**Lower Blacks Fork**
Normal	Spring	17	43	287	697	1	1,536	56	0	-	0	1
	Summer	37	101	729	204	2	255	1,853	0	-	0	0
	Fall	9	17	141	92	0	100	268	0	-	0	0
Dry	Spring	12	58	72	133	1	292	141	0	-	0	6
	Summer	28	88	7	0	2	172	385	0	-	0	0
	Fall	5	13	2	20	0	58	55	0	-	0	0
Wet	Spring	56	79	73	1,201	5	1,393	532	0	-	0	5
	Summer	49	538	592	1,436	4	2,746	56	0	-	0	3
	Fall	14	60	70	394	1	249	583	0	-	0	0

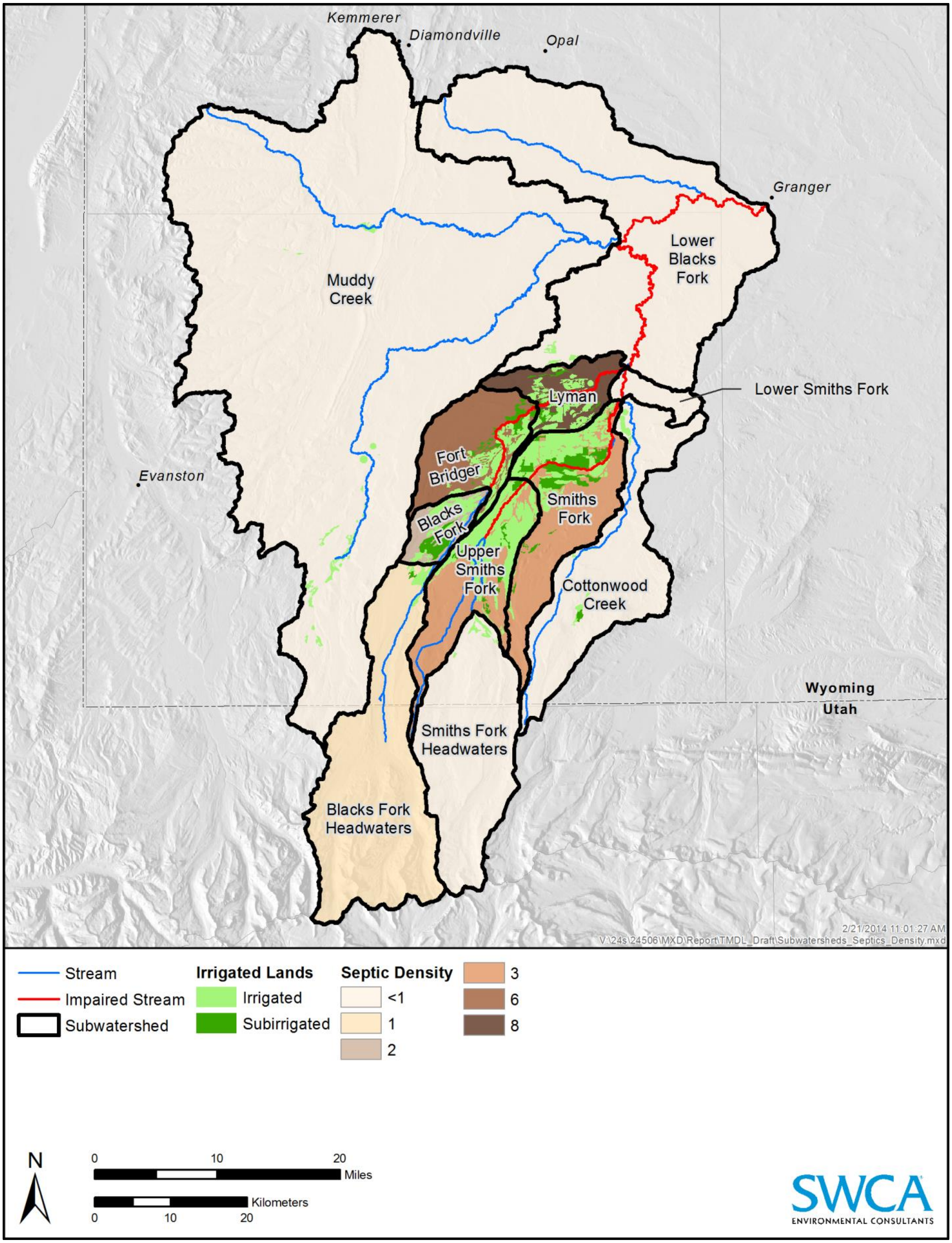

Figure 2.10. Septic system location and density in the Blacks Fork Watershed.

2.1.2.3.4. Pet Waste

Pet waste contribution to *E. coli* loading occurs from stormwater runoff from residential lawns, dog parks, and other typically urban landscapes where impervious surfaces are prevalent. Due to the rural nature of the Blacks Fork Watershed, pet waste contribution is small compared to other sources, even in the more populated subwatersheds of Fort Bridger, Lyman, and Smiths Fork (Table 2.14). However, as these rural communities become more developed, pet waste could increasingly become a significant source. As such, it is important to consider the current magnitude and origin of *E. coli* from pet waste and include it as a source to be reduced.

Table 2.14. Pet Waste Loads (G-cfu/season) for each Subwatershed during the Nine Hydrologic Regimes

Hydrologic Regime		Subwatershed										
Climate	Season	Blacks Fork Headwaters	Blacks Fork	Fort Bridger	Lyman	Smiths Fork Headwaters	Upper Smiths Fork	Smiths Fork	Cottonwood Creek	Lower Smiths Fork	Muddy Creek	Lower Blacks Fork
Normal	Spring	4	6	77	346	0	147	17	0	4	0	0
	Summer	8	14	195	100	1	24	548	0	1	0	0
	Fall	2	2	38	46	0	10	79	0	0	0	0
Dry	Spring	3	8	19	66	0	28	42	0	0	0	1
	Summer	6	12	2	0	0	16	114	0	0	0	0
	Fall	1	2	1	9	0	5	16	0	1	0	0
Wet	Spring	12	11	19	597	1	133	157	0	1	0	1
	Summer	11	74	158	714	1	262	17	0	36	0	1
	Fall	3	8	19	196	0	24	173	0	1	0	0

2.1.3. Source Load Summary

E. coli loads by both point source and nonpoint source are presented below for each subwatershed during spring, summer, and fall of the normal climate condition (Table 2.15–2.17). The total load for the entire impairment season can be viewed in Table 2.18. Nonpoint source loads were examined as a percentage of total nonpoint source loads, revealing that livestock contribute to *E. coli* loads in subwatersheds of Reach 1 and Reach 4 (Figure 2.11). Upstream loads add significant contributions, particularly in the Lyman and Lower Smiths Fork subwatersheds. Diverted loads are highest in Lyman and Smiths Fork, whereas septic systems contribute noticeable loads in Fort Bridger subwatershed. Inputs from wildlife are greatest in the Blacks Fork Headwaters and Cottonwood Creek subwatersheds.

Table 2.15. Summary of *E. coli* Loads during a Normal Spring Hydrologic Regime (G-cfu/season [May–June])

Subwatershed	Upstream	Diverted	Septic	Pet Waste	Wildlife	Livestock	Total Nonpoint Source	Point Source	Total
Blacks Fork	803	–	43	6	221	6,114	7,186	–	7,186
Blacks Fork Headwaters	0	–	17	4	1,459	303	1,783	–	1,783
Cottonwood Creek	0	–	0	0	21	59	80	–	80
Fort Bridger	1,106	–	287	77	719	10,249	12,439	36	12,475
Lower Blacks Fork	1,095	–	1	0	309	966	2,371	–	2,371
Lower Smiths Fork	27,887	–	0	4	2,444	11,971	42,306	–	42,306
Muddy Creek	0	–	0	0	26	162	188	–	188
Smiths Fork	23,823	1,290	56	17	146	2,541	27,873	15	27,888
Smiths Fork Headwaters	0	–	1	0	481	123	605	–	605
Lyman	9,805	1,266	697	346	1,009	16,770	29,892	90	29,982
Upper Smiths Fork	0	0	1,536	147	3,786	66,828	72,297	–	72,297

Table 2.16. Summary of *E. coli* Loads during a Normal Summer Hydrologic Regime (G-cfu/season [July–August])

Subwatershed	Upstream	Diverted	Septic	Pet Waste	Wildlife	Livestock	Total Nonpoint Source	Point Source	Total
Blacks Fork	2,683	–	101	14	523	14,480	17,801	–	17,801
Blacks Fork Headwaters	0	–	37	8	3,263	3,302	6,611	–	6,611
Cottonwood Creek	0	–	0	0	4	12	16	–	16
Fort Bridger	0	–	728	195	1,826	13,079	15,828	14	15,842
Lower Blacks Fork	183	–	0	0	111	141	436	–	436
Lower Smiths Fork	42,175	–	0	1	460	1,114	43,750	–	43,750
Muddy Creek	0	–	0	0	4	14	18	–	18
Smiths Fork	5,390	15,307	1,853	548	4,824	72,331	100,253	101	100,354
Smiths Fork Headwaters	0	–	2	1	979	742	1,724	–	1,724
Lyman	10,429	3,806	204	101	295	1,750	16,585	95	16,680
Upper Smiths Fork	0	–	255	24	629	6,543	7,451	–-	7,451

Table 2.17. Summary of *E. coli* Loads during a Normal Fall Hydrologic Regime (G-cfu/season [September])

Subwatershed	Upstream	Diverted	Septic	Pet Waste	Wildlife	Livestock	Total Nonpoint Source	Point Source	Total
Blacks Fork	317	–	17	2	89	2,477	2,903	–	2,903
Blacks Fork Headwaters	0	–	9	2	807	136	955	–	955
Cottonwood Creek	0	–	0	0	1	3	4	–	4
Fort Bridger	480	–	141	38	354	2,632	3,646	6	3,651
Lower Blacks Fork	28	–	0	0	27	40	96	–	96
Lower Smiths Fork	6,540	–	–	0	30	71	6,641	–	6,641
Muddy Creek	0	–	0	0	1	2	3	–	3
Smiths Fork	2,279	2,599	268	79	698	10,641	16,565	7	16,573
Smiths Fork Headwaters	0	–	0	0	151	122	273	–	273
Lyman	1,161	334	92	46	133	801	2,567	60	2,627
Upper Smiths Fork	0	–	100	10	247	2,652	3,008	–	3,008

Table 2.18. Summary of Total *E. coli* Loads during a Normal Climate Condition (G-cfu/season [May-September])

Subwatershed	Upstream	Diverted	Septic	Pet Waste	Wildlife	Livestock	Total Nonpoint Source	Point Source	Total
Blacks Fork	3,804	-	161	22	833	23,071	27,891	-	27,891
Blacks Fork Headwaters	-	-	64	14	5,530	3,742	9,349	-	9,349
Cottonwood Creek	-	-	0	0	27	73	100	-	100
Fort Bridger	1,586	-	1,157	309	2,900	25,960	31,913	55	31,968
Lower Blacks Fork	1,306	-	1	0	448	1,148	2,903	-	2,903
Lower Smiths Fork	76,602	-	-	5	2,934	13,156	92,697	-	92,697
Muddy Creek	-	-	0	0	31	178	209	-	209
Smiths Fork	31,492	19,196	2,178	644	5,668	85,512	144,691	123	144,814
Smiths Fork Headwaters	-	-	4	1	1,610	987	2,602	-	2,602
Lyman	21,395	5,406	992	493	1,437	19,321	49,045	245	49,290
Upper Smiths Fork	-	-	1,892	180	4,662	76,022	82,756	-	82,756

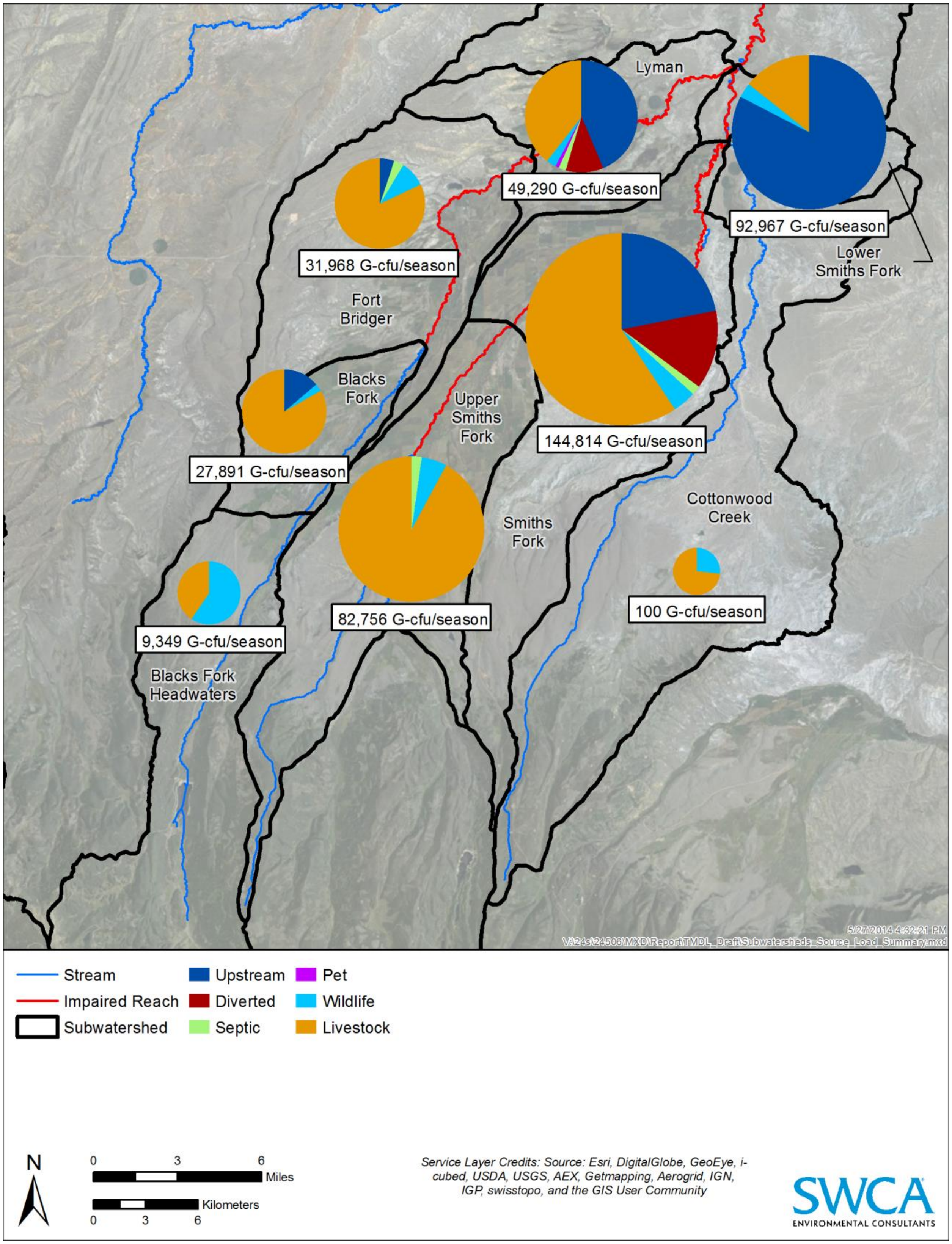

Figure 2.11. Source loads by subwatershed during a normal climate condition.

2.2. Load Reduction Estimates (element b)

The TMDL identifies the need to reduce pathogens from sources by 65% in Reach 1, 71% in Reach 3, and 86% in Reach 4 during the normal climate impairment season (May–September). For Reach 1, a 65% reduction translates to a reduction of the *E. coli* load of 38,912 G-cfu/season. For Reach 3, a 71% reduction translates to 65,815 G-cfu/season. or Reach 4, an 86% reduction equates to 168,627 G-cfu/season. Tributaries contributing loads to impaired reaches will also require a reduction. For Blacks Fork Headwaters and Blacks Fork subwatersheds, a 65% reduction is required, translating to a reduction load of 6,077 and 18,128 G-cfu/season, respectively. For Cottonwood Creek, a 71% reduction is required, resulting in a 71 G-cfu/season load reduction. Required percentage reductions, load reductions, and resulting load capacities are presented in Table 2.19.

Table 2.19. Load Reductions (G-cfu) Calculated for each Subwatershed for the Normal Climate Condition During the Impairment Season (May–September)

Impaired Reach	Compliance Point	Percentage Reduction	Load Reduction	TMDL
1	Lyman, Fort Bridger	65%	38,912	20,952
3	Lower Smiths Fork	71%	65,815	26,882
4	Upper Smiths Fork, Smiths Fork	86%	168,627	27,451
Contributing Tributaries	Blacks Fork Headwaters	65%	6,077	3,272
	Blacks Fork	65%	18,129	9,762
	Cottonwood Creek	71%	70	29

Load allocations (LAs) were identified for each impaired water and contributing tributary in the Blacks Fork Watershed. Impaired reaches consisting of more than one subwatershed (Reach 1 and 4) were given compliance points, identified as the most downstream point of each subwatershed in the impaired reach. Although the Lower Blacks Fork subwatershed (Reach 2) is listed as impaired, the data indicate that there is no impairment, therefore Lower Blacks Fork and Muddy Creek subwatersheds were not included in the LA process or implementation plan. Additionally, because there is no upstream *E. coli* load from Smiths Fork Headwaters, it was also not included in the LA process.

Nonpoint source LAs represent the remaining load capacity after WLAs and future LAs have been accounted for. The nonpoint source LA was used to calculate a percentage reduction for each subwatershed that was then applied to all nonpoint sources to generate individual LAs per source (Table 2.20). During the normal climate impairment season, upstream LAs are greatest for Reach 3, whereas livestock LAs are greatest for Reach 1 and Reach 4 (Figure 2.12).

Table 2.20. Load Allocations (G-cfu) Calculated for each Compliance Point for the Normal Climate Condition During the Impairment Season (May–September)

Impaired Reach	Compliance Point*	Upstream LA	Diverted LA	Septic LA	Pet Waste LA	Wildlife LA	Livestock LA	Total LA
1	Lyman, Fort Bridger	534	1,819	723	270	1,460	15,239	20,046
3	Lower Smiths Fork	22,215	–	0	1	851	3,815	26,882
4	Upper Smiths Fork, Smiths Fork	0	2,621	556	113	1,410	22,053	26,753
Contributing Tributaries	Blacks Fork Headwaters	0	–	22	5	1,932	1,307	3,266
	Blacks Fork	1,329	–	56	8	291	8,061	9,746
	Cottonwood Creek	0	–	0	0	8	21	29

* Compliance points are identified as the most downstream point of each subwatershed in the impaired reach.

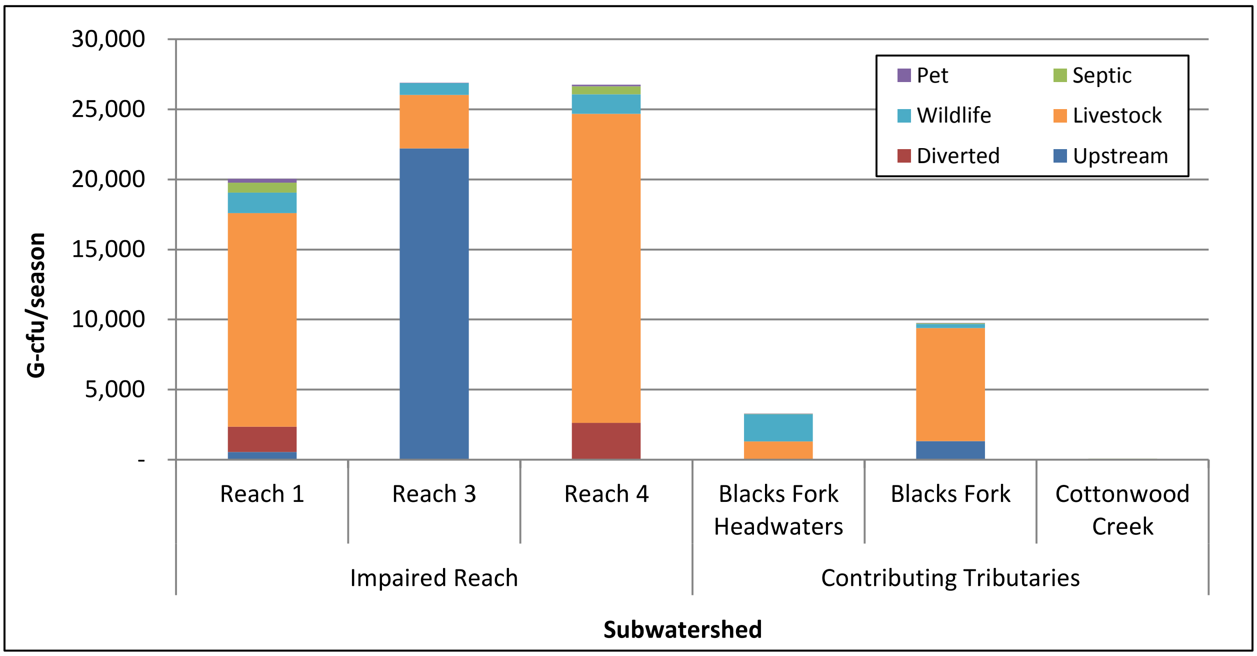

Figure 2.12. Nonpoint source load allocations for each subwatershed.

2.3. Recommended Implementation Measures and Key Areas (element c)

2.3.1. Point Sources

Point sources of *E. coli* in the Blacks Fork Watershed consist of three WWTPs in the Lyman, Fort Bridger, and Smiths Fork subwatersheds, and a truck stop off Interstate 80 called Travel Centers of America. The Lyman and Fort Bridger plants discharge to drainages connected to the Blacks Fork River, whereas the Mountain View plant discharges directly to the Smiths Fork River. Travel Centers of America is not currently discharging effluent and has no future plans to discharge; therefore, it is not considered in the implementation plan. There are no current plans to upgrade any of the WWTPs; however, periodic *E. coli* concentration exceedances have been observed in the DMR report for all three

WWTPs and will be discussed below. Given that all treatment plants in the Blacks Fork Watershed are currently operating below load allocations, no load reduction is required.

2.3.1.1. FORT BRIDGER SEWER

Under a normal climate condition, the current wastewater load from the Fort Bridger Sewer District is 47 G-cfu/season compared to the allocated load of 257 G-cfu/season. The treatment plant typically operates well below the permitted load under all climate conditions; however, *E. coli* concentration exceedances have been observed in the DMR data.

2.3.1.2. TOWN OF LYMAN

The current wastewater load from the Lyman Wastewater Lagoon is 245 G-cfu/season under a normal climate condition compared to the 423 G-cfu/season that is allocated to this source. DMR data show that Lyman has discharged effluent with concentrations above what is permitted; however, the WLA is not being exceeded. For six of the nine hydrologic regimes, average *E. coli* concentrations are above 126 cfu/100 mL, with the highest average value of 483 cfu/100 mL occurring during a summer-dry regime. The Lyman Wastewater Lagoon is working with the WDEQ to mitigate effluent *E. coli* concentrations, which exceed the permitted allowance. Doing so will be necessary to comply with the WLA.

2.3.1.3. TOWN OF MOUNTAIN VIEW

The current wastewater load from the Mountain View Wastewater Lagoon is 123 G-cfu/season under a normal climate condition compared to the 431 G-cfu/season WLA. Although this facility is currently meeting the allocation, historical data show that *E. coli* concentration exceedances do occur. However, the recent construction of a new facility will target those high concentrations such that exceedances are properly mitigated.

2.3.2. Nonpoint Sources

Many of the future implementation measures and recommended BMPs discussed herein were adopted from the *Blacks Fork & Smiths Fork Rivers Watershed Management Plan* (UCCD 2005). This management plan was created in 2005 by the UCCD and the Blacks Fork/Smiths Fork Water Quality Steering Committee to proactively address existing water quality concerns and also to ensure the future protection of water resources. It offers a detailed and comprehensive approach to providing solutions to various contaminant sources in addition to listing interested parties and sources of funding. Many of the recommendations detailed below build on suggestions from this 2005 plan. Additional BMPs were selected using standard practices developed by the NRCS (NRCS 2013) and a region-specific irrigation analysis that explored various technologies for the Blacks Fork region. Although key areas are identified in each source as locations to implement recommended BMPs, it should be noted that BMP implementation can be conducted throughout the entire Blacks Fork Watershed. BMP implementation to address nonpoint sources can assist in improving waters quality in impaired reaches and can also maintain water quality in unimpaired reaches.

2.3.2.1. IRRIGATION

The load analysis indicates that irrigation activities contribute to a portion of *E. coli* loading, particularly in the Smiths Fork and Lyman subwatersheds. The nonpoint source nature of irrigation on private land may require voluntary and active cooperation of private landowners to achieve the stated reductions.

2.3.2.1.1. Existing Implementation Measures

UCCD's 2005 watershed management plan identified irrigation as a critical component of the local agricultural economy and sought to devise a strategy for improving the viability of the agricultural industry while also enhancing water quality. These objectives include both information and education components as well as implementing structural BMPs. Since 2005, several irrigation projects have taken place, most as a joint effort between the NRCS and private landowners. In 2009, three irrigation improvement projects occurred in the Blacks Fork Watershed in which irrigation practices were converted from flood to sprinkler, affecting 1,621 acres. In 2010, four irrigation projects were implemented that affected a total of 380 acres. Specifically, these projects involved improving irrigation systems through installing pivots and over 11,300 feet of pipeline. Additionally, the U.S. Fish and Wildlife Service (USFWS) worked with a private landowner to create a wetland using irrigation wastewater. This project also involved maintenance and improvement on upland areas.

2.3.2.1.2. Future Implementation Measures

Irrigation improvement is active in the Blacks Fork Watershed, and an extension of those improvement activities that holistically addresses range management, riparian health, and irrigation would be helpful for pathogen reduction success. Table 2.21 provides a list and description of practices that have shown to effectively reduce *E. coli* loading in other watersheds. Additionally, the irrigation analysis explored various sprinkler irrigation options such as a linear system, wheel line, and a hand line but concluded that the center pivot method was most conducive to the Blacks Fork region. The limiting factor is that this technology can only be implemented in landscapes where topography allows and is best left to the judgment of local stakeholders. If properly designed and managed, it is possible to achieve a 70%–95% application efficiency (Rogers et al. 1997).

Table 2.21. Recommended Implementation Measures for Irrigation Improvement in Feasible Locations

Recommended BMPs	Description
Sprinkler irrigation	Irrigate croplands through more efficient use of sprinkler technologies.
Irrigation water management	Determine and control the volume, frequency, and application rate of irrigation water in a planned and efficient manner.
Tailwater recovery/reuse	Install an irrigation system that captures irrigation runoff for reuse.
Microirrigation	Apply water in an efficient, targeted, and uniform way through emitters placed along a water delivery line.

2.3.2.1.3. Key Areas

The recommended implementation strategies could be most effective in those subwatersheds where higher *E. coli* loads are occurring. Smiths Fork and Lyman have been identified as receiving large *E. coli* loads; however, it is those subwatersheds with large diverted loads that should also be mitigated. In addition to Smiths Fork and Lyman, Upper Smiths Fork, Blacks Fork, and Fort Bridger subwatersheds are recommended as areas of focus for implementing irrigation BMPs in landscapes where feasible (Figure 2.13).

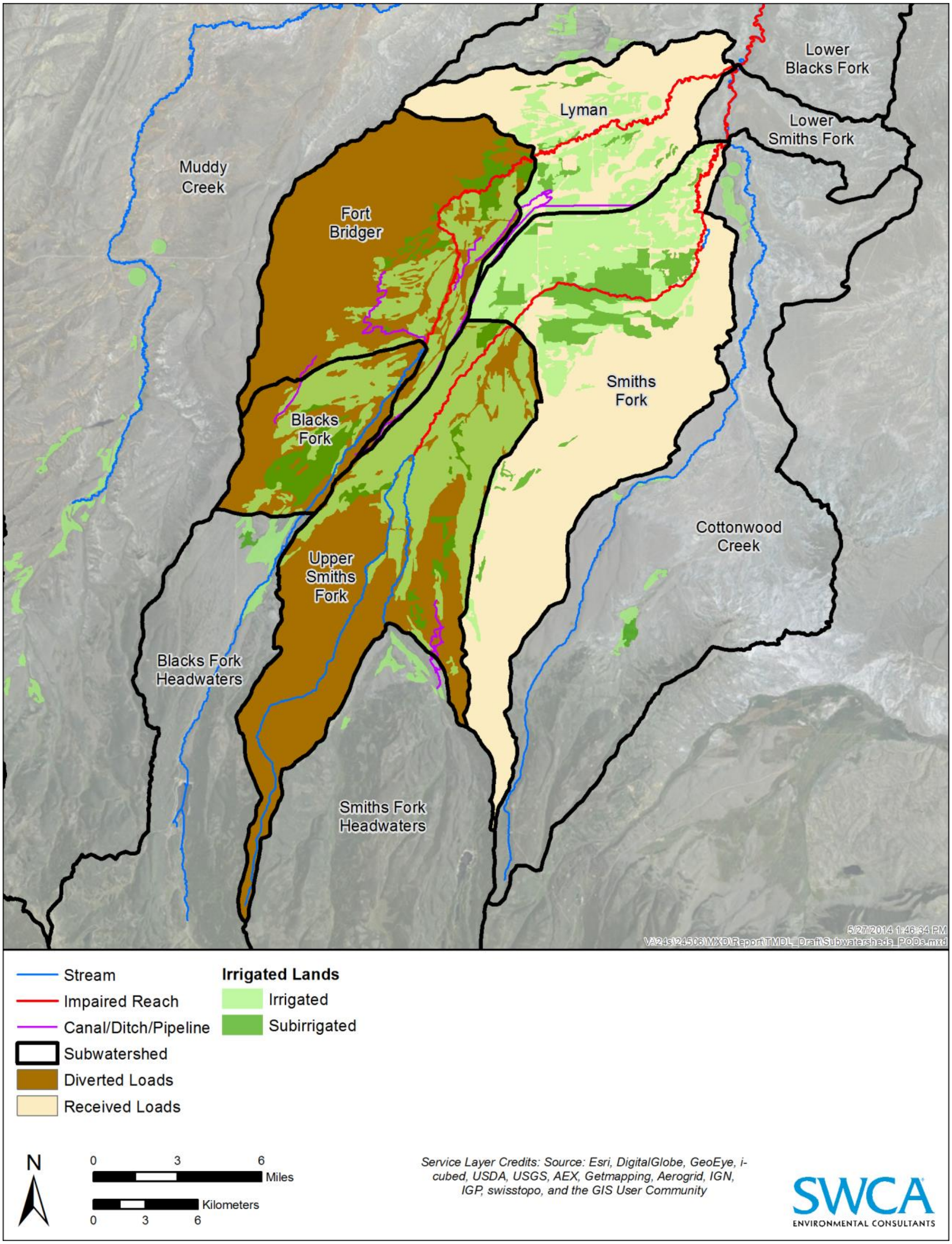

Figure 2.13. Key areas for implementing irrigation best management practices.

2.3.2.2. LIVESTOCK GRAZING

A variety of implementation measures are available to assist stakeholders in addressing *E. coli* loading from livestock grazing on both public and private land. Due to the differences in landownership and current management strategies, public lands and private lands will be addressed separately, assuming a similar percentage reduction in total load.

2.3.2.2.1. Public Land Grazing

Publicly administered grazing allotments account for approximately 88% of total allotment acreage in the Blacks Fork Watershed. Most of this land is managed by the BLM; however, some active USFS allotments exist in the Smiths Fork Headwaters and Blacks Fork Headwaters. BLM, USFS, landowners, and local governments should continue to work together to maintain and improve on current successful land management strategies, particularly in the headwaters and upstream subwatersheds, in order to be protective of downstream waters.

2.3.2.2.1.1. Existing Implementation Measures

The BLM evaluates allotment health on an ongoing basis using a variety of both qualitative and quantitative assessment methods. All allotments are required to meet the BLM's *Standards and Guidelines of Rangeland Health*, which addresses the health, productivity, and sustainability of public rangelands through four metrics: 1) properly functioning watersheds; 2) naturally cycling water, nutrients, and energy; 3) acceptable air and water quality; and 4) viable habitats for special-status species (BLM 2001). When allotments fail to meet these standards on account of livestock impacts, corrective measures must be taken within 1 year. Corrective measures are implemented depending on the type of degradation that occurred but could include installing alternative water sources, incorporating active herding or timed rotation of livestock to reduce impact duration, installing riparian fencing, or planting willows and other riparian vegetation.[2] An additional guideline tool is the *Record of Decision and Approved Kemmerer Resource Management Plan* developed for the BLM Kemmerer Field Office. It was approved in May 2010 (BLM 2010) and outlines land use planning and management direction to inform future actions.

USFS allotment management relies primarily on the *Revised Forest Plan Wasatch-Cache National Forest* (U.S. Department of Agriculture [USDA] 2003). The forest plan provides guidelines to encourage the management of healthy watersheds by maintaining the ecological integrity of aquatic ecosystems and by supplying safe water for drinking and recreation (USDA 2003). Livestock grazing guidelines include forage use, adaptive management to attain desired conditions for vegetation and aquatic resources, and riparian habitat conservation. The purpose of the revised forest plan is to guide all natural resource management plans for the forest based on desired future conditions. Additionally, annual range operating plans exist for individual grazing allotments. The annual range operating plans vary by allotment but outline livestock management activities to protect the watershed and ensure healthy conditions. These plans include various management strategies such as forage levels to ensure adequate vegetation levels, grazing rotations, grazing capacity guidelines, and rules for how far salt should be placed from surface waters to reduce the likelihood of runoff. Specific range improvements are listed in the operating plan annually to ensure that proper management occurs.

[2] Personal communication between Bashia Trout (BLM) and Lucy Parham (SWCA) on February 13, 2014.

2.3.2.2.1.2. Future Implementation Measures

In conjunction with current successful management efforts, the following BMPs are recommended as possible mitigation strategies for reducing *E. coli* loading: range management, off-site water troughs to limit animal contact with surface waters, and fencing to provide livestock exclusion from waterways.

2.3.2.2.1.3. Key Areas

Key areas to focus efforts for public grazing include the active USFS allotments in the Blacks Fork Headwaters subwatershed. Although this subwatershed is not impaired, it is contributing a load of *E. coli* to downstream subwatersheds that are impaired and therefore should be considered as a key source. BLM-managed grazing allotments in the Upper Smiths Fork, Smiths Fork, Lower Smiths Fork, and Fort Bridger subwatersheds should also be considered provided that high *E. coli* loads are occurring there and these subwatersheds primarily consist of BLM-administered grazing allotments (Figure 2.14).

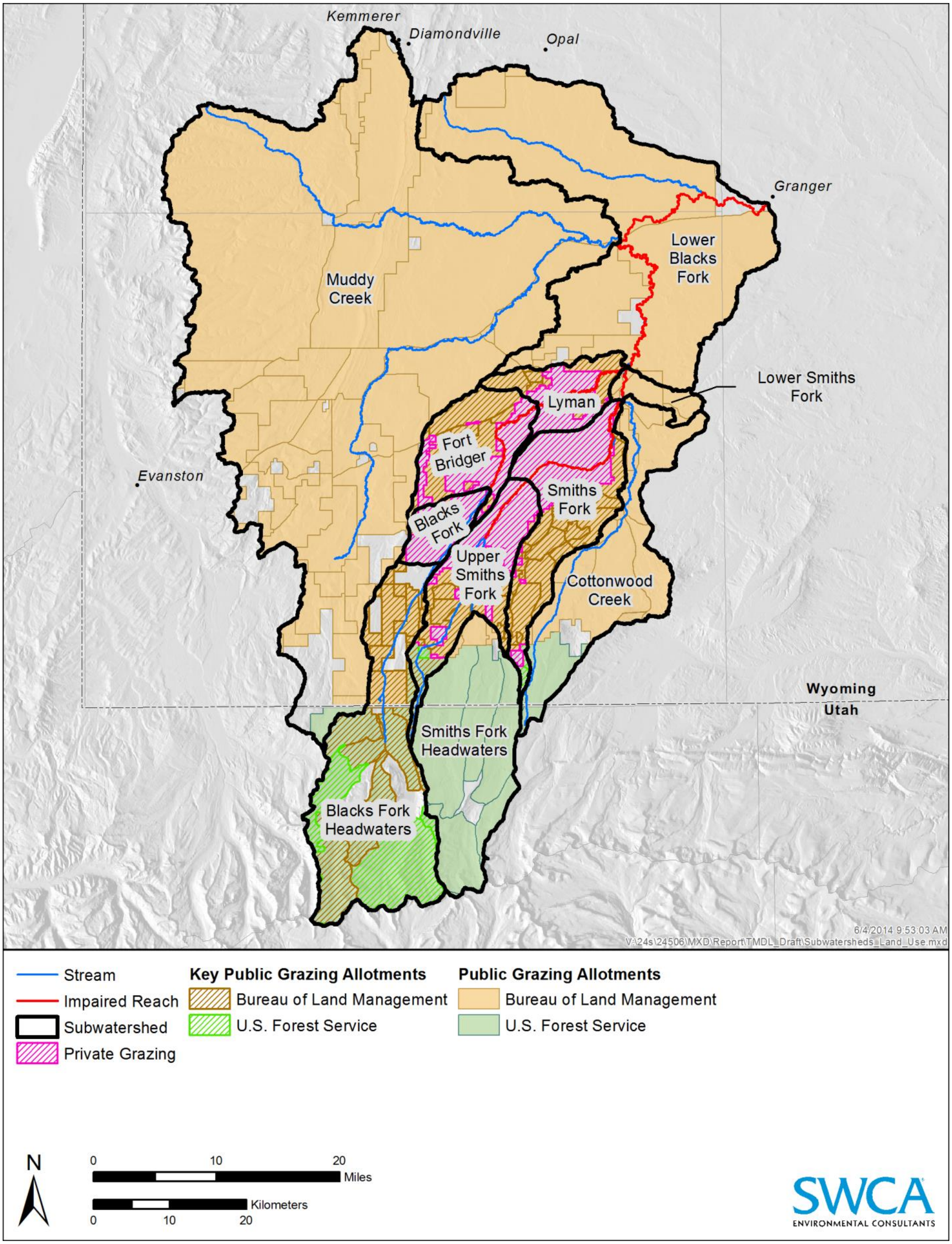

Figure 2.14. Key areas for both public and private grazing.

2.3.2.2.2. Private Land Grazing

The load analysis indicates that pastured animals on private land contribute to a portion of *E. coli* loading, particularly in Blacks Fork, Lyman, Fort Bridger, and Smiths Fork subwatersheds. The nonpoint source nature of grazing on private land may require voluntary and active cooperation of private landowners to achieve the stated reductions.

2.3.2.2.2.1. Existing Implementation Measures

Several nonpoint source management efforts have been made in the Blacks Fork Watershed, specifically to more evenly distribute livestock and wildlife away from riparian areas. In 1994, landowners and permittees in the Willow Creek drainage area (tributary to Smiths Fork) came together with the UCCD to form a working group that included the BLM, NRCS, UCCD, Uinta County Cattlewomen, USFS, Wyoming Department of Agriculture, Wyoming Fish and Game Department, the Wyoming State Forester, and several private landowners to develop the *Willow Creek Coordinated Resource Management Plan* (WCCRMP). The aim of this plan was to improve water quality and habitat for the Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*); however, it also created a platform from which joint, coordinated strategies between several entities could be developed to achieve stated goals. Specifically, the WCCRMP addressed resource management of 23,025 acres of the Willow Creek watershed and used BLM-approved management options that included intensive herding, salting, fencing, changing season of use, redistributing livestock use, and changing stocking rates and animal types (cow/calf to yearling) (Wyoming Department of Agriculture 2009). Additionally, off-site watering was developed on surrounding upland areas to move cattle and wildlife away from creek bottoms. It included the creation of stock water ponds/reservoirs, pipelines and wells, and spring development. These efforts have seen great success in the Willow Creek watershed, as evidenced through a healthier upland range that is habitat for wildlife as well as streambank stabilization and enhanced water quality that have led to a stable Colorado River cutthroat trout population (Wyoming Department of Agriculture 2009). Furthermore, Willow Creek has been a hub for encouraging community involvement and hosting educational events for both students and watershed residents alike. The BLM continues to monitor the area and works with WCCRMP team members as needs arise.

UCCD's 2005 watershed management plan identifies agriculture as a vital component of the local economy and seeks to devise a strategy for improving the viability of the agricultural industry while also enhancing water quality. The objectives of the plan include both information and education components as well as implementing structural BMPs and working with the USFS and BLM to enhance publicly administered grazing allotments. Enhancement of grazing management practices was used as a tool to improve water quality through streambank stabilization and riparian areas protection. Since 2005, several grazing management projects have taken place under the oversight of various stakeholder groups. In 2009 and 2010, three animal feeding operation (AFO) improvement projects occurred on the Blacks Fork and Smiths Fork as a joint effort between the UCCD and private landowners. AFO improvement is an active, current cost-share program provided by the UCCD and has made great strides in reducing the effect of AFOs on water quality. In 2010, USFWS assisted a private landowner with an off-stream livestock development that enhanced 24 acres of land and 5,400 feet of stream. In a separate project, they also installed fencing to prevent livestock from accessing 2 acres of riparian land.

2.3.2.2.2.2. Recommended Implementation Measures

Reaching the target allocation goal will be a product of both current measures and future strategies that involve implementing a variety of grazing management BMPs. Efforts by the UCCD with the AFO program are hugely beneficial and should continue moving forward. The first step in this effort should be working with NRCS to document all of the existing projects that have been completed for livestock in the watershed. Continuing the outreach and educational programs for livestock owners could also help raise awareness about the potential impacts of grazing. The UCCD and NRCS could provide landowners with education about riparian buffer technologies, as well as cost-share assistance through the USDA, UCCD, and NRCS to landowners wanting to improve properties. These BMPs could include range management, brush management, range planting, livestock exclusion, and riparian plantings and could be selected based on the interest and needs of local stakeholders. Table 2.22 provides a list and description of those practices that have shown to effectively reduce pathogen loading in other watersheds.

Table 2.22. Recommended Implementation Measures for Grazing on Private Land

Recommended BMPs	Description
Range management	Manage the harvest of vegetation with grazing animals to optimize landscape health.
Livestock exclusion	Distribution of livestock away from riparian areas
Riparian buffer strips	Protect the natural riparian buffer along the streambank.

2.3.2.2.2.3. Key Areas

Key areas to focus private grazing efforts include the Lyman, Fort Bridger, Blacks Fork, Upper Smiths Fork, and Smiths Fork subwatersheds. The source analysis conducted in the TMDL identified these subwatersheds as exhibiting high *E. coli* loads from livestock, and they consist largely of privately owned land where cattle and sheep are grazed. Additionally, much of this same landscape is flood irrigated and may be acting as a transport mechanism to move *E. coli* to surface waters (see Figure 2.14).

2.3.2.3. WILDLIFE

The load analysis indicates that wildlife are a significant contributor of *E. coli*, particularly in the Blacks Fork Headwaters and tributaries such as Cottonwood Creek. Complex seasonal migration patterns and a lack of understanding of where and when wildlife spend most of their time make identifying the most effective BMP installations locations difficult. Successful *E. coli* load reduction requires action from both public and private stakeholder groups.

2.3.2.3.1. Recommended Implementation Measures

Developing a better grasp on herd movement patterns in the Blacks Fork Watershed is crucial for implementing BMPs that will be effective. Generally speaking, measures for herd management may need to be taken to control herd sizes and distribution. Herd management may include the relocation of some herd members or simply the creation of alternate off-channel watering facilities away from streams. Other areas of high priority are springs, riparian areas of headwaters, and other sensitive habitats. Protecting these areas by fencing or by alternative off-channel watering facilities will help to ensure the headwater tributaries are supplying clean water to the larger systems.

2.3.2.3.2. Key Areas

Reaching LA goals will require focusing efforts in areas of high-density wildlife populations near or in riparian areas, particularly in Blacks Fork Headwaters and Cottonwood Creek subwatersheds (Figure 2.15). Although neither of these reaches is currently impaired, both are feeding downstream portions that do exhibit impairment. Furthermore, the livestock BMPs implemented in many of the inner, low-lying subwatersheds will also be protective against wildlife influence. Priority should also be placed along streams that have unstable banks or poor riparian vegetation.

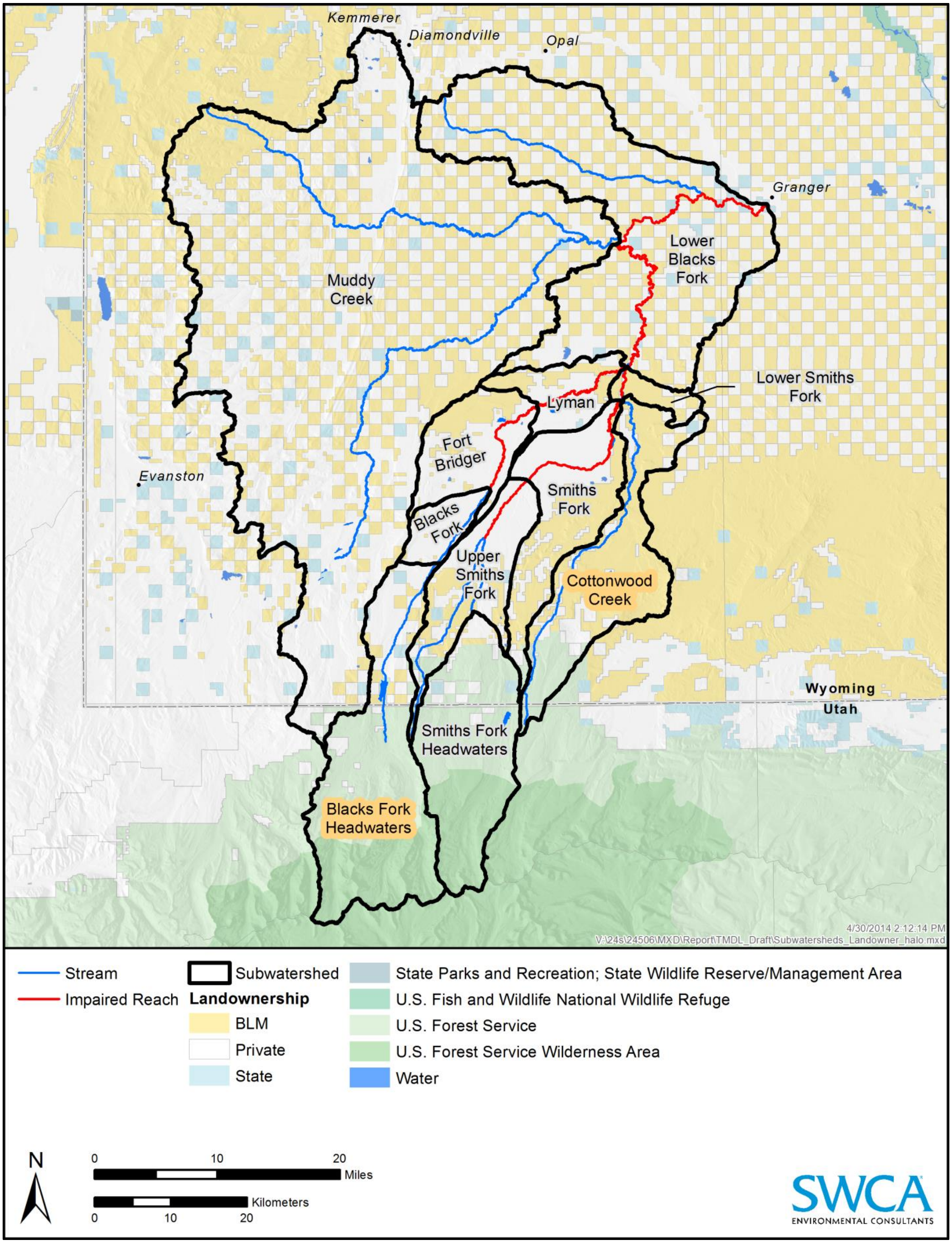

Figure 2.15. Key subwatersheds for implementing wildlife best management practices.

2.3.2.4. SEPTIC SYSTEMS

Septic systems have the potential to contribute high *E. coli* loads to receiving waters, particularly in landscapes where irrigation occurs and can interact with leach fields. Although the load analysis does not identify septics as a primary *E. coli* contributor in the Blacks Fork Watershed, as the population increases, septic system contribution will inevitably become more significant and should be managed for presently.

2.3.2.4.1. Existing Implementation Measures

UCCD's 2005 watershed management plan identifies septic systems as potential contributors of pathogens to surface waters and lays out several measures to reduce loading. Measures include information and education efforts that involve sending educational mailings to homeowners within 100 feet of a stream, distributing a homeowner's guide to septic system owners, and hosting a workshop to increase support and participation in a septic remediation cost-share program. Since the plan development, several septic upgrades have taken place, including two projects on the Blacks Fork and one project on the Smiths Fork in 2009 and another project on the Blacks Fork in 2010. Funding remains available to support these projects; however, participation has waned, increasing the need for more aggressive information and education efforts.

2.3.2.4.2. Future Implementation Measures

Continuing to build on the UCCD septic remediation program is important for ensuring pathogen reductions. Additionally, given the amount of irrigated lands in many of the subwatersheds, it is recommended that a "mounding system" replace traditional septic system drain fields. Mounding systems are useful in landscapes where highly permeable soils exist and/or a high water table occurs that prevents the necessary percolation needed to allow for adequate purification. A "mounded" septic allows for slow absorption of effluent providing needed pathogen removal. It is recommended that these systems be installed in place of any conventional septic systems that are within an irrigated landscape. Implementation of these measures will generally cost between $5,000 and $10,000, including maintenance over 10 years.

Furthermore, it is recommended that a watershed-wide septic inventory and mapping exercise be conducted by the appropriate regulatory entity. The information gained from these efforts could be used to create a planning database that the UCCD could reference for identifying high-priority areas and further focusing remediation efforts. A preliminary database is provided in this implementation document but could be further refined with ground-truthing and additional surveying. Figure 2.16 provides a step-by-step process for conducting an inventory and inspection protocol that can be used to create a database that will document progress and inform future mitigation strategies. More details for each step are provided after the figure.

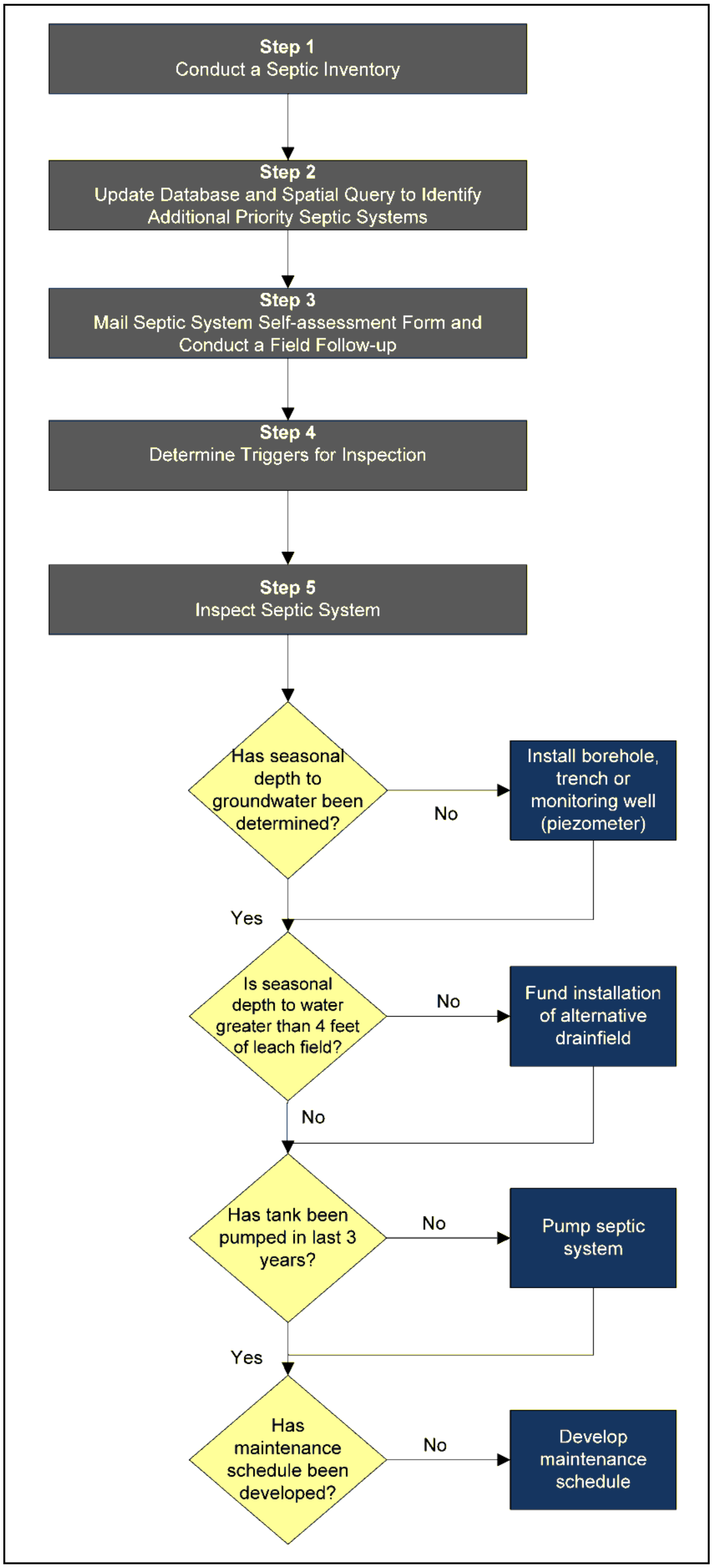

Figure 2.16. A systematic approach for developing a septic system inventory and inspection program.

2.3.2.4.2.1. Step 1. Conduct a Septic Inventory

The preliminary database provided below is a strong starting point for developing a comprehensive septic database that documents location, age, and status. The initial analysis provided used aerial imagery, combined with a geographic information system (GIS) layer of known septic systems, to identify additional developed parcels. Ground-truthing of this aerial photography exercise would be helpful for confirming septic system existence and for adding any other developments that may have been overlooked. A septic tank inventory list would provide managers the information necessary to identify high-priority areas to focus project efforts and to maximize implementation effectiveness.

2.3.2.4.2.2. Step 2. Update Database and Spatial Query to Identify Additional Priority Septic Systems

The septic system priority list should be updated following Step 1. The intersection of several GIS layers has been queried to identify the number and location of septic systems in priority areas. These layers include the existing septic system inventory layer, an aquifer sensitivity layer, a created layer for a 100-meter buffer adjacent to the creeks, and irrigated landscapes.

After the inventory has been completed in Step 1, this query should be updated to identify priority septic systems.

2.3.2.4.2.3. Step 3. Mail Septic System Self-Assessment Form and Conduct a Field Follow-Up

Landowners identified in Step 2 as having “high-priority” septics should be contacted and mailed an assessment form that gathers general information regarding system age, type, and location in the landscape. Initially, these mailings should focus on septic systems located in key areas that combine the three attributes: 1) within 100 meters of the creek, 2) in aquifer sensitivity areas (see Figure 2.16), and 3) in irrigated landscapes. If the landowner does not complete and return the form, field visits will be necessary to assist the landowner in filling out the form.

Subsequent mailings should be sent to landowners that have septic systems that are located in additional key areas: 1) within 100 meters of the creek, 2) in aquifer sensitivity areas, or 3) in irrigated areas. Following these mailings would be mailings to all remaining landowners that have septic systems.

2.3.2.4.2.4. Step 4. Determine Triggers for Inspection

A septic system inspection program should be initiated. Management is an important issue for the successful performance of any on-site septic system. Part of that management is having septic tanks inspected and pumped on a regular basis. The frequency of required maintenance will vary due to the capacity of the septic tank and water usage. Periodic inspections can determine the current conditions of the tank, and whether maintenance is required to obtain proper functioning.

Inspection triggers would be determined from information gathered through the assessment forms. Information that would trigger septic system inspections includes the following:

- The location of the septic tank is unknown.
- The location of the drain field is unknown.
- The depth to season high groundwater is less than 4 feet.
- The septic tank is undersized for the size of the household.
- The septic system is older than 25 years.
- There is an impermeable surface such as concrete, asphalt, or brick located over the drain field.

- Septic odors are present.
- Ponding or wastewater breakout is present.
- Burnt-out grass or ground staining is present over the drain field.
- Patches of lush green grass are present over the drain field.
- Pipes are exposed at or near the ground surface.
- Cracks or signs of leakage are present in risers and lids.
- There is an apparent cave-in or exposed component identified.

2.3.2.4.2.5. Step 5. Inspect Septic System

This step includes a series of decision points used to evaluate the condition of the septic system. Using the information from Step 4, certain septic systems should be inspected. The first step in Step 5 is to determine if the seasonal high groundwater level has been determined. If not, a borehole, trench, or monitoring well (small 1-inch pipe, or piezometers) is needed. If the seasonal high groundwater level is less than 4 feet beneath the drain field, an alternative drain field should be designed and constructed. Water separation systems should be considered. One way to reduce septic system discharge is to reduce the volume of water passing through the system. This can be achieved by separating reusable water (e.g., showers, hand washing, sump pumps, and laundry) from highly contaminated water such as sewage. This reusable water is known as *gray water*, which can be used in Wyoming as subirrigation for trees and gardens. The use of gray water in Wyoming requires a permit from the Water and Wastewater Program. The next step is determining whether or not the septic tank has been pumped. The final step is determining a maintenance schedule for the septic system.

A successful and effective septic system management plan requires that the septic tank (or tanks) must be located on each property. This is particularly important for septic tanks located in priority areas, as described above (e.g., within 100 meters of the creek, in aquifer sensitivity areas, or in irrigated areas). If the location of the septic tank (or tanks) is not known, a maintenance plan cannot be implemented.

There are several methods available to locate a septic tank. The building permit for the home or the original septic system permit may show the location of the septic tank. If the septic tank is not shown on any permits, probes may be used to locate the tank. A probe (such as a metal rod) can be used to trace the pipeline from the house or by listening to the noise a plumber's snake makes when it contacts the tank inlet. Care must be used during probing to prevent damaging the inlet tees or piping. Another probing method used to locate septic tanks involves using a small diameter 0.5-inch galvanized pipe approximately 6 feet long and threaded to a garden hose. With the water turned on, the pipe is used to “jet” a hole into the ground and sound for the tank. If these methods fail, small radio transmitters can be used to locate the septic tank. The transmitters are flushed down the toilet, and a receiver is used to locate the transmitter inside of the tank. Once the tank is uncovered and opened, the transmitter can be retrieved.

Locating septic tanks can alert managers of improperly functioning systems or even illegal systems such as straight pipes. Creating an inventory and inspection, and developing a maintenance schedule of septic systems, can reduce pathogen loads without construction of new treatment facilities.

2.3.2.4.3. Key Areas

The areas of greatest concern are those with high-density septic tanks close to streams and in flood-irrigated landscapes. Placement of septic tanks in areas of high aquifer sensitivity is also a priority (Table 2.23). The series of maps below illustrates septic system locations and identifies proximity to streams, septics within an irrigated or subirrigated landscape, and septics in an area of high aquifer sensitivity (Figure 2.17). The last map exhibits those septic locations that have all three attributes and are considered a "high priority" (see Figure 2.17). Upper Smiths Fork subwatershed has the highest number of high-priority septics at 120, followed by Fort Bridger (83), Smiths Fork (74), and Lyman (69). High-priority septics should be the initial focus of implementation efforts.

Table 2.23. Septic Systems on Irrigated Land and in a High Aquifer Sensitivity Landscape within 100 meters of an National Hydrography Dataset–Identified Stream

Subwatershed	High-Priority Septics	Aquifer Sensitivity	Septics within 100 Meters of the Creek	Septics on Irrigated Lands
Blacks Fork	10	36	13	16
Blacks Fork Headwaters	9	35	22	3
Cottonwood Creek	0	0	1	0
Fort Bridger	83	301	115	83
Lower Blacks Fork	1	3	5	0
Lower Smiths Fork	0	0	0	0
Muddy Creek	1	1	24	5
Smiths Fork	74	313	86	147
Smiths Fork Headwaters	3	3	10	0
Lyman	69	180	121	80
Upper Smiths Fork	120	215	130	158

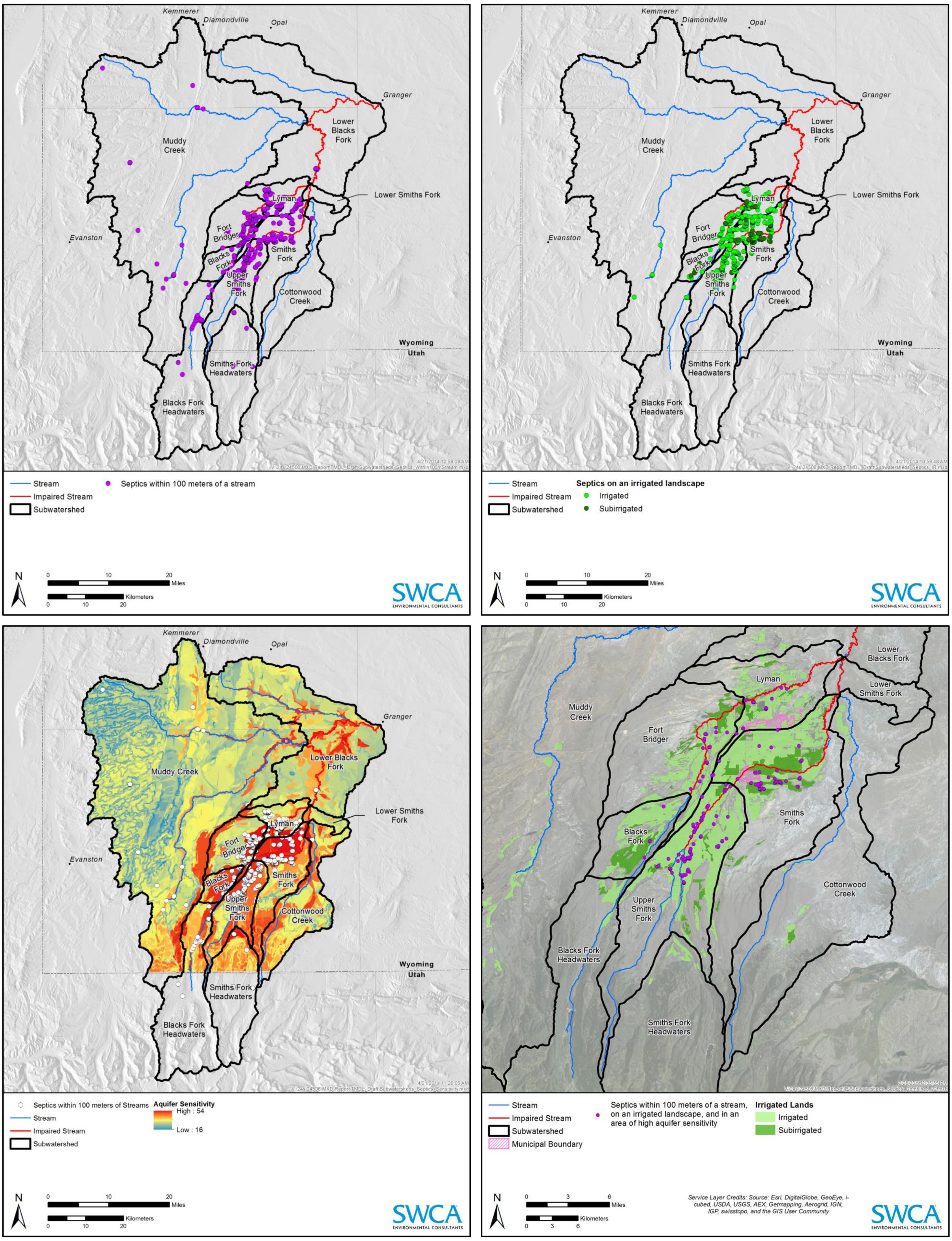

Figure 2.17. Location of septic systems in the Blacks Fork watershed.

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2.3.2.5. PET WASTE

Compared to other sources, pet waste contributes a small portion of the total *E. coli* load to surface waters. However, as urban development and impervious surface increase in the Blacks Fork Watershed, the likelihood of pet waste becoming a more significant source also increases. Although no structural BMPs are recommended at this time, it is important to focus on information and educational outreach to citizens of the Lyman, Mountain View, and Fort Bridger communities. Taking preventative actions toward reducing pet waste will decrease the likelihood of it becoming a greater source in the future. Recommended information and education BMPs are discussed below (section 2.5.1.3).

2.3.2.6. UPSTREAM

Upstream loads account for a large percentage of total *E. coli* loads, particularly in the Lyman and Lower Smiths Fork subwatersheds. Reduction of these loads could be addressed through implementation of the recommended BMPs for those subwatersheds that are upstream of receiving subwatersheds. For example, the 83% upstream load contribution in Lower Smiths Fork is a product of *E. coli* loading in the Smiths Fork and Upper Smiths Fork subwatersheds (see Figure 2.4). Pathogen reductions achieved in those two subwatersheds (Upper Smiths and Smiths Fork) could be sufficient to reduce the upstream load entering the Lower Smiths Fork subwatershed. As such, no implementation measures are recommended for the upstream load in the Lower Smiths Fork subwatershed itself.

2.3.3. Best Management Practices Implementation Summary

Below is a summary of recommended BMP suites by source as well as the potential combined effectiveness and the key areas for implementation (Table 2.24). Those subwatersheds throughout the Blacks Fork Watershed that are currently contributing to higher loads are also highlighted. Generally speaking, within each identified subwatershed, landscapes (or septics) close to streams should be a high priority for BMP implementation. Public and private grazing costs were apportioned based on the amount publicly and privately managed land.

Table 2.24. Summary of Best Management Practices Application in the Blacks Fork Watershed

E. coli **Source**	**Recommended BMP Suite**	**Combined BMP Effectiveness**	**Key Subwatersheds**
Irrigation	Sprinkler, buffer strips, irrigation water management, recovery/reuse, microirrigation	70%–95%	Lyman, Fort Bridger, Upper Smiths Fork, Smiths Fork
Private land grazing	Range management, livestock distribution away from surface waters, buffer strips	80%–90%	Blacks Fork, Lyman, Fort Bridger, Upper Smiths Fork, Smiths Fork
Public land grazing	Range management, livestock distribution away from surface waters, buffer strips	80%–90%	Blacks Fork Headwaters, Fort Bridger, Upper Smiths Fork, Smiths Fork, Lower Smiths Fork
Wildlife	Wildlife exclusion, riparian buffers	85%–95%	Blacks Fork Headwaters, Cottonwood Creek
Septic systems	Upgrades	80%–90%	Fort Bridger, Lyman, Upper Smiths Fork, Smiths Fork

2.4. Technical and Financial Needs (element d)

Successful implementation relies on various technical and financial needs as well as a strong foundation of plan sponsors that will be responsible for actual on-the-ground work. A thorough understanding of these needs is important for creating a clear path forward that will ensure long-term operation and maintenance of management measures, information and educational activities, and monitoring.

Implementation of the management measures and BMPs necessary to meet the water quality goals outlined in the TMDL requires a significant allocation of financial and technical resources from multiple sources. Cost-benefit studies are recommended as a tool for identifying the most cost-effective strategies to prioritize throughout the Blacks Fork Watershed. The implementation plan and costs outlined in Table 2.25 are a general guide and are not intended to be a comprehensive list of costs associated with all potential BMPs or resources. The estimated total cost for implementing recommended BMPs throughout the Blacks Fork Watershed is $39,479,484 (see Table 2.25). Costs were calculated with a non-linear, generalized reduced gradient algorithm (Solver Microsoft Excel 2010) that was set to minimize costs while also achieving *E. coli* load reductions. Total costs were calculated as the average of the sum of the minimum and maximum costs for selected BMPs applied to the areas determined by the generalized reduced gradient algorithm. Final decisions on project implementation will be made by local land managers and owners based on their intimate knowledge of specific areas of the watershed.

Table 2.25. Summary of Financial and Technical Needs to Implement Best Management Practices Suites for the Blacks Fork Total Maximum Daily Loads

E. coli **Source**	**Recommended BMP Suite**	**Technical Needs**	**Financial Needs**	**Project Sponsors**	**Sources of Potential Funding**
Irrigation	Sprinkler, buffer strips, irrigation water management, reuse/recovery, microirrigation	Professional technical advisory on placement, maintenance	$33,786,085	UCCD, NRCS, private landowners	NRCS Environmental Quality Incentive Program (EQIP); 319/EPA
Private grazing	Range management, livestock distribution away from surface waters, buffer strips	Professional technical advisory on placement	$81,777 for private grazing	UCCD, NRCS, private landowners	EQIP; 319/EPA
Public grazing	Range management, livestock distribution away from surface waters, buffer strips	Professional technical advisory on placement	$599,696 for public grazing	BLM, USFS	EQIP; 319/EPA
Wildlife	Wildlife exclusion, riparian buffers	Professional technical advisory on placement	$322,512	USFS, BLM, USFWS	EQIP; 319/EPA
Septic systems	Upgrades	Engineering, maintenance	$4,689,414	UCCD, watershed residents	UCCD; 319/EPA

2.4.1. Plan Sponsors and Resources

Stakeholders that will be involved in technical assistance and execution of the implementation plan include the following: UCCD, NRCS, USFS, BLM, USFWS, private landowners, and watershed residents.

Interagency coordination between local, state, and federal entities is an integral part of this implementation plan. The NRCS and UCCD will assist in coordination between the State of Wyoming and willing private landowners to address source issues on private land. For agriculture, BMP implementation is a voluntary, incentive-based program. Federal cost-share incentives are available through programs such as the NRCS Environmental Quality Incentive Program (EQIP) as well as EPA 319 funding that specifically address nonpoint sources. Other sources of funding used in the past include the Wyoming Landscape Conservation Initiative, Wyoming Wildlife and Natural Resource Trust, Ducks Unlimited, Partners for Fish and Wildlife, and Wyoming Department of Agriculture. Continued participation from private landowners, managers, and all stakeholders in the watershed is important to the successful outcome of this implementation plan.

2.5. Information and Education (element e)

2.5.1. Purpose and Approach

The purpose of the information and education component is to attain water quality standards through implementation of TMDL *E. coli* load reductions by public outreach and by encouraging participation in the implementation plan. The methodology for this process is built on identifying various stakeholder groups and developing outreach strategies that will be most effective for encouraging groups to participate. Within each audience, related sources are identified and solicitation strategies such as outreach, training, information, and assistance to specific demographics throughout the Blacks Fork Watershed are presented.

2.5.1.1. PRIVATE LANDOWNERS

Continuing coordinated efforts with private landowners will play an important role in reducing pathogen loading. The NRCS and UCCD have a strong presence with private landowners in the Blacks Fork Watershed. It is recommended that they continue to work with individuals who own land that is used for grazing and/or crop production, particularly those that have land directly adjacent to surface waterways. Furthermore, conducting a survey of streams where cattle have direct access to waterways and focusing implementation efforts there will increase the likelihood of restoring stream health. Hosting a workshop to inform landowners on BMPs and available funding through cost-share programs and other sources would assist in spreading knowledge and increasing participation.

2.5.1.2. SEPTIC SYSTEM OWNERS

Encouraging homeowners to participate in an inventory, inspection, and upgrade plan for septic systems throughout the subwatersheds will be helpful for reducing septic load contribution. The systematic approach described in section 2.3.2.4 will make it easier to organize and increase participation among local watershed residents.

2.5.1.3. LOCAL SCHOOL EDUCATION PROGRAMS

Educating and involving future residents of the Blacks Fork Watershed about watershed health is important for the continued success of implementation efforts. Visiting local schools and presenting data in a fun and creative way can generate excitement and ownership of local water resources. The UCCD is currently active in the local school districts and has successfully completed several outreach and education projects. These projects have included hosting several "World Water Monitoring Day" with many students and volunteer participants and an outdoor education class centered on water quality monitoring. They regularly make classroom visits to teach children about nonpoint source pollution, watersheds, and the water cycle.

2.5.1.4. TOURS OF SUCCESSFUL IMPLEMENTATION PROJECTS

The audience for this goal consists of citizens of the Blacks Fork Watershed who may be interested in volunteering time or property for future restoration projects. The objective of this goal is to increase awareness of the benefits of septic remediation projects, AFO enhancement, and irrigation efficiency. There are several successful implementation projects conducted by private agricultural land owners in conjunction with UCCD and NRCS that could be used as an example of proper land use practices. Successful implementation projects would make a great tour for landowners in other parts of the watershed and would also provide an opportunity for landowners to exchange concerns and experiences with one another directly.

2.5.2. Create the Message

Although specific tailored messages will be developed for each stakeholder group, there are primary messages that will be distributed across all audiences. The following are the primary messages that will be communicated throughout all information and education plan efforts:

- Excess *E. coli* loading to surface waters causes the current pathogen impairments observed in three reaches of the Blacks Fork Watershed.
- *E. coli* load reductions rely on both point and nonpoint source implementation measures.
- Strategies to protect water resources can also benefit range and riparian health as evidenced by current successful land stewardship practices conducted by watershed residents.
- Information concerning all watershed management activities should be made accessible to watershed residents online.

2.5.3. Distribute the Message

A variety of methods are available for successfully distributing messages throughout the watershed. Workshops, trainings, informational materials, presentations, and lectures are all ways to engage local stakeholders and successfully deliver both primary and secondary messages related to pollution management. Specifically, developing brochures that condense the issue and relay it in a way that is useful for watershed residents will be an important component for successful implementation. This grass-roots approach is relatively inexpensive but can be hugely effective for mobilizing residents. Implementation becomes most effective when stakeholder groups work together to identify and execute practices that are agreeable to all parties. Successful efforts such as those of the UCCD and NRCS in reaching out to private landowners to encourage beneficial land use are important for achieving information and education goals.

2.6. Implementation Schedule (element f and g)

To ensure that water quality targets are attained, a series of milestones and a schedule for their completion are helpful for tracking progress as implementation is carried out in the Blacks Fork Watershed. Identified milestones and the corresponding schedule are presented in Table 2.26.

Table 2.26. Implementation Milestones and Schedule for the Blacks Fork Watershed

Implementation Tasks	Indicator	Milestone (short term–2017)	Milestone (medium term–2024)	Completion Date (long term–2029)
GOAL: Alter Irrigation Practices to be more Efficient.				
Improve irrigation efficiency in locations where topography allows.	Number of projects completed	5	10	15
GOAL: Assist the USFS and BLM in Implementing Specific Recommendations for Grazing on Public Land.				
Implement BMPs on public land.	Number of projects completed	10	15	20
GOAL: Assist Private Landowners in Obtaining Funding to Enhance Range Management.				
Implement BMPs on private land.	Number of projects completed	5	10	15
GOAL: Assist the BLM and USFS in Implementing Specific Recommendations for Wildlife Grazing on Public Lands.				
Implement BMPs to distribute wildlife away from riparian area.	Number of projects completed	10	15	20
GOAL: Reduce Septic Tank Contributions to Impairments.				
Conduct a septic inventory for the entire watershed using aerial photographs and ground-truthing, and update septic database. Refine spatial queries for final priority septic map.	Updated spatial database of all septic permits	1 updated database	0	0
Mail self-assessment forms to septic system owners and follow decision matrix described in Figure 2.16 to determine upgrades.	Number of septic systems owners contacted and addressed voluntarily using steps identified in Figure 2.16	150	300	600
GOAL: Inform and Educate.				
Host workshops on agricultural BMPs and available funding sources.	Number of workshops	1	1	1
Host septic system workshops to inform homeowners of proper care and maintenance.	Number of septic system workshops per year	1	1	1
Conduct a watershed tour of septic system upgrade projects and AFOs.	Number of tours held	1	1	1
Develop a materials check-out program for local schools to access water quality and watershed management materials.	Number of teachers that check out materials	2	10	50

2.7. Loading Reduction Targets (element h)

The water quality criterion required to determine if load reductions are being achieved for the summer recreation season (May 1–September 30) states that concentrations of *E. coli* bacteria should not exceed a geometric mean of 126 cfu/100 mL during any consecutive 60-day period (Table 2.27). This water quality criterion is derived directly from the water quality standards for bacteria established by the State of Wyoming. *E. coli* is the bacteria parameter with a numeric water quality standard for Wyoming waters. In 1986, the EPA recommended that *E. coli* replace fecal coliform bacteria in state water quality standards (EPA 1986). This recommendation is reflected in current Wyoming water quality standards and in the water quality targets identified for this TMDL.

Table 2.27. Criteria to Assure Implementation Plan will Achieve Water Quality Targets

Indicators to Measure Progress	Target Value or Goal	Short Term (3 years)	Medium Term (10 years)	Long Term (15 years)
E. coli average 60-day geomean	126 cfu/100 mL	400 cfu/100 mL	200 cfu/100 mL	126 cfu/100 mL

2.8. Monitoring (element i)

The monitoring goals of this project are to document progress in achieving improved water quality conditions in four reaches of the Blacks Fork Watershed as nonpoint source control management strategies are implemented. Specifically, the objectives are as follows:

- Obtain information necessary to ensure that *E. coli* loading and concentration targets for *E. coli* are met.
- Obtain a detailed record of water quality data to assess whether the established target levels and threshold values are protective of designated uses.
- Evaluate BMP effectiveness and load reductions that result from implementation efforts.

Successful development and implementation of the monitoring plan will provide flexibility for adapting to new information and changes in the watershed.

To document this progress, a monitoring program is needed to examine and report on the performance of each management strategy. Two types of performance monitoring are proposed in this implementation plan: 1) implementation monitoring and 2) effectiveness monitoring. Implementation monitoring assesses whether the proposed management strategies were implemented and, if they have been implemented, the progress that has been achieved. Effectiveness monitoring is used to check if the selected strategies are effectively reducing pollutant loading. The following subsections present implementation and effectiveness monitoring methods proposed for organizations that will be involved in execution of this implementation plan.

2.8.1. Implementation Monitoring

Each organization should monitor implementation of management strategies by tracking the progress and accomplishments of each activity. A centralized database could be used by organizations to monitor implementation of the proposed management strategies. The database could initially be constructed around existing water quality data and landscape characteristics as well as the implementation strategies proposed in this plan. Additionally, maintaining a status column for each strategy that indicates current progress would also be useful. Other types of information should include the following:

- Implementation strategy lead/coordinator
- Source being addressed and subwatershed where it is occurring
- Resources procured, spent, or still needed
- Possible funding sources
- Timeline for implementation

Success of this type of monitoring will rely heavily on appointing a single agency/entity to be responsible for both building and updating database content as work is conducted.

2.8.2. Effectiveness Monitoring

Effectiveness monitoring is used to check if the selected strategies are reducing pathogen loading. Effectiveness monitoring may be quantitative (e.g., laboratory analysis of pathogen concentrations in water from specific catchments, or in water exiting private property or developments) or qualitative (e.g., visual observation of sediment reduction in the water passing through a fenced riparian area), depending on the BMP implemented and the overall scope of the project. Although quantitative monitoring methods will document progress toward improved conditions, qualitative methods can also provide an effective measurement of implementation progress. Techniques such as photo-documentation of a site pre- and post-implementation or documenting relative sediment volume (i.e., high, medium, or low) collected from a detention pond will illustrate progress and can be combined with other monitoring efforts to show success of implementation activities. Quantitative effectiveness monitoring is required to document actual progress toward improved water quality conditions and can only be achieved through water quality assessments. Therefore, the success in reducing the load of *E. coli* will be measured by concentrations monitored at static sampling points in each impaired reach.

2.8.2.1. SAMPLING DESIGN AND PARAMETERS

The quantitative monitoring plan requires water quality monitoring of sites located throughout the watershed that contribute directly to the annual pathogen load. To assist in achieving the water quality goals, the initial monitoring plan should include the following:

- Seasonal monitoring throughout the year at catchment delineation points and major irrigation canals and monitoring the selected sites for pathogens and discharge
- Monitoring streams above and below large BMP installation projects to determine effectiveness of individual projects

During the impairment season, effective quantitative monitoring will require a seasonal sampling regime that captures varying hydrological conditions due to natural runoff and irrigation practices. The irrigation seasons previously defined in this study are recommended as the most appropriate timeframe for collecting samples because *E. coli* loads are generated around these seasons and because they represent the 60 days in which the *E. coli* standard is set. Those seasons were defined as spring (May, June), summer (July, August), and fall (September). It is recommended that August data be included with September data to capture the 60-day geomean for the fall season. Collecting an adequate number of samples per season would be sufficient to determine load reduction progress. Any additional samples taken during these time periods are encouraged, particularly during storm events and before and after BMP implementation. Spatially, all 11 subwatersheds should be sampled at the subwatershed delineation point, with particular attention to Muddy Creek and Lower Blacks Fork subwatersheds where data are scarce.

2.8.3. Additional Data Needs

2.8.3.1. GROUNDWATER

Due to the probable relationship between irrigation runoff and leach fields, data documenting this interaction would be extremely helpful. To collect data to determine the effect of irrigation on leach fields, a series of groundwater wells should be established around 10 representative leach fields (in high and low groundwater-sensitivity areas and in irrigated and non-irrigated areas of the watershed) throughout the watershed where water quality samples and well level data would be gathered. The wells could be placed at increasingly greater distances from the leach field to determine the area of impact. To obtain representative data, samples should be collected before, during, and after an irrigation event. It may also be applicable to install piezometers around the leach field to determine the direction of groundwater flow before sampling wells are installed.

These data would provide information about the relationship between irrigation runoff and leach fields. In particular, they would help determine whether irrigation water flushes leach fields and/or dilutes contaminants. This information could then be used in refining priorities for septic improvement projects.

2.8.3.2. SOURCES

2.8.3.2.1. Wildlife

Further refinement of source loads from wildlife would be helpful, particularly with regard to seasonal migrations. Currently, known seasonal movements are very broad and lack the specificity needed to accurately quantify seasonal loadings. Furthermore, locations need to be identified where animals congregate or spend large amounts of time. A first step would be to conduct wildlife estimates during winter months when big-game animals are most likely to be in higher densities and easier to locate. In areas of known high densities of wildlife populations, exclosures could be placed on the property to determine the levels of wildlife grazing or impact for that area.

These data could be used to provide a more reliable estimate of wildlife contributions to *E. coli* loads. If these loads were determined to be a significant input, efforts could be undertaken by wildlife officials to relocate problem animals or design programs to control herd sizes. Collecting data on big-game populations would also be beneficial to allow TMDL targets to be specified for different types of wildlife sources.

2.8.3.2.2. Livestock

Currently, there are no reliable estimates for the numbers of livestock grazing on private land in the watershed. Further refining of these numbers would allow for a more accurate characterization of source contribution and a better approach for implementing BMPs. On public grazing land, linear transects could be established to identify quantity of fecal deposits. These transect estimates could be used to identify grazing intensity as well as potential problem areas. For AFOs or other high-density operations, visual assessments should be completed that could identify obvious problems areas such as livestock in stream, unstable streambanks, no riparian buffer along the streambank, manure storage facilities close to the stream, etc. If livestock distribution and quantity can be identified in a watershed, multiple analyses are available to estimate the potential loading from that population. With more accurate loading estimates, areas could be more easily recognized and prescribed grazing plans could be applied to areas of high risk.

2.8.3.3. DNA SOURCE TRACKING

Several analyses are currently available to more accurately differentiate sources of *E. coli* in the landscape. DNA source tracking is at the forefront of these cutting-edge technologies in that it can clearly and accurately identify the relative contribution of primary sources of pathogen loading. DNA source tracking is the state-of-the-art method for microbial source identification both for the TMDLs and direct implementation of BMPs (EPA 2002). It is a proven, documented, and effective method for quantifying the relative contributions of varying sources to microbial loads, and it has been used in a number of TMDLs such as the Lower Boise River, Idaho and Four Mile Run, Virginia (EPA 2002; Simpson et al. 2002; Vogel et al. 2007; EPA 2011). At a minimum, this method can provide a quantifiable distinction between human, bovine livestock, and other (e.g., wildlife) sources. DNA source tracking can also allow for an understanding of how pathogen sources change over the course of a season. This deeper level of understanding could improve future implementation planning in the Blacks Fork Watershed by allowing for more focused implementation efforts at greater cost efficiency.

3. CONCLUSIONS

Addressing nonpoint sources in the manner detailed in this implementation plan and summarized below (Table 2.28) could result in *E. coli* load reductions that are important for enhanced water quality and that support beneficial uses in the impaired reaches in the Blacks Fork Watershed. The detailed approach outlined in this plan provides a comprehensive, effective formula that builds on current stakeholder efforts and infrastructure to address each nonpoint source successfully. Furthermore, the cost analysis and identification of sponsors provide a clear path forward for carrying out recommended BMP suites and ensuring that work can be efficiently completed. The Wyoming Coordinated Resource Management Plan conducted by livestock permittees, private landowners, and the BLM on 5,000 acres of Willow Creek is a prime example of the type of cooperative, collaborative work that will protect water resources in perpetuity (Wyoming Department of Agriculture 2009). It is the hope that this implementation plan could be used by enthusiastic, engaged stakeholders as a roadmap for working together to protect quality and health of the Blacks Fork and Smiths Fork and enhancing the management of the watersheds that support them.

Table 2.28. Summary of Best Management Practice Application in the Blacks Fork Watershed

***E. coli* Source**	**Current *E. coli* Load (G-cfu/season)**				**Project Sponsors**	**Recommended Information and Education**	**Recommended BMP Suite**	**Combined BMP Effectiveness**	**Estimated Cost ($ over 15 years)**	**Key Subwatersheds**
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**						
Irrigation	5,406	No reduction required	0	19,196	UCCD, NRCS, USFWS, private landowners	Workshops on agricultural BMPs and funding sources	Sprinkler irrigation, buffer strips, water management, reuse/recovery, microirrigation	70%–95%	$33,786,085	Lyman, Fort Bridger, Upper Smiths Fork, Smiths Fork, Blacks Fork
Private land grazing	45,105	No reduction required	13,156	161,494	UCCD, NRCS, USFWS, private landowners	Workshops on agricultural BMPs and funding sources	Range management, livestock distribution away from surface waters, buffer strips	80%–90%	$81,777	Blacks Fork, Lyman, Fort Bridger, Upper Smiths Fork, Smiths Fork
Public land grazing	Included in private load	No reduction required	Included in private load	Included in private load	BLM, USFS	Provide support to BLM and USFS	Range management, livestock distribution away from surface waters, buffer strips	80%–90%	$599,696	Blacks Fork Headwaters, Fort Bridger, Upper Smiths Fork, Smiths Fork, Lower Smiths Fork
Wildlife	4,319	No reduction required	2,934	10,327	BLM, USFS, USFWS	Provide support to BLM, USFS, USFWS	Wildlife exclusion, riparian buffers	85%–95%	$322,512	Blacks Fork Headwaters, Cottonwood Creek
Septic systems	2,137	No reduction required	0	4,069	UCCD, watershed residents	Workshops and self-assessment mailings	Upgrades	80%–90%	$4,689,414	Fort Bridger, Lyman, Upper Smiths Fork, Smiths Fork
Pet waste	796	No reduction required	5	824	UCCD, watershed residents	Public education program to increase awareness	Information and Education	N/A	N/A	Fort Bridger, Lyman, Smiths Fork

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